# AERONAUTICAL ENGINEERING REVIEW

INSTITUTE OF THE AERONAUTICAL SCIENCES

DECEMBER 1950

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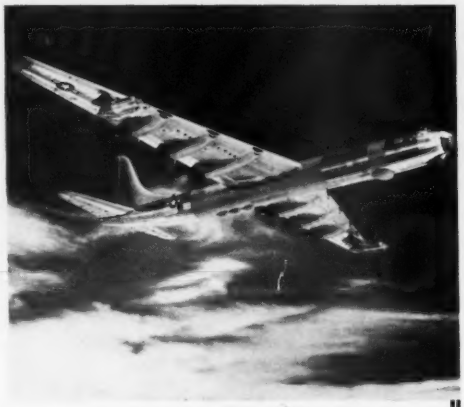

Cover—Convair's RB-36 reconnaissance airplane is equipped with four General Electric J-47 jet engines, in addition to six Pratt & Whitney 3,500-hp. piston engines.


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# AERONAUTICAL ENGINEERING REVIEW


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# I. A. S. News

*A Record of People and Events of Interest to Institute Members*


# I.A.S. President for 1951, Rear Adm. L. B. Richardson, U.S.N. (Ret.)

## *New President Succeeds "Dutch" Kindelberger; New Vice-Presidents Include R. D. Kelly, W. C. Rockefeller, W. T. Schwendler, and E. C. Wells. E. E. Aldrin Named Treasurer.*

LAWRENCE BAXTER RICHARDSON, Rear Admiral, U.S.N. (Ret.), was elected President of the Institute of the Aeronautical Sciences for the year 1951 at the October 26 meeting of the Council. He succeeds James Howard "Dutch" Kindelberger, Chairman of the Board, North American Aviation, Inc., who has guided the affairs of the Institute during 1950. Admiral Richardson's election conforms with the I.A.S. policy of rotating this office between East and West Coast leaders every other year.

▸ **Other Elected Officers**—Vice-Presidents for the ensuing year are: Raymond Douglas Kelly, Superintendent of Technical Development, United Air Lines, Inc.; William Curtis Rockefeller, Assistant to the Chairman of the Board, Consolidated Vultee Aircraft Corporation; William Theodore Schwendler, Executive Vice-President and Director, Grumman Aircraft Engineering Corporation; and Edward Curtis Wells, Vice-President of Engineering, Boeing Airplane Company. The new Treasurer is Edwin Eugene Aldrin, Aviation Manager, Atlas Supply Company. The Council also re-elected S. Paul Johnston as Director, Robert R. Dexter as Secretary, and Joseph J. Maitan as Controller.

These men will take office during the Nineteenth Annual Meeting at the Hotel Astor, New York City, January 29 to February 1, 1951.

▸ **The President**—Admiral Richardson, Director of Research and Development, Fairchild Engine and Airplane Corporation, is eminently qualified to supervise the affairs of the Institute of which he is a Fellow and former member of the Council. He has had exceptionally broad experience in the design, development, manufacture, and inspection of aircraft, as well as a long career in Naval Aviation.

Born in Swampscott, Mass., on January 13, 1897, Admiral Richardson entered the U.S. Naval Academy in 1914 and was commissioned an Ensign in the U.S. Navy 3 years later. After a tour of duty during World War I on the U.S.S. "Huntington," he completed a postgraduate course at the Massachusetts Institute of Technology and was graduated in 1921 with a Master of Science degree in Naval Construction. He received flight training at Pensacola Naval Air Station, Fla., and was qualified in 1925 as a Naval Aviator on all types of Naval aircraft.

Over a period of years, Admiral Richardson was assigned both to the Construction Corps and to aeronautical engineering, being attached to the former in 1919 and to the latter in 1922, in which year his career in aeronautics began.

Thereafter he was continuously associated with Naval Aviation and the aircraft industry until he retired from active duty in 1946. He served in various engineering, industrial, and administrative capacities at aircraft plants, at sea, at Naval Air Stations, at the Naval Aircraft Factory, and at the Bureau of Aeronautics. He received flight training at Pensacola Naval Air Station and was qualified in 1925 as a Naval Aviator in all types of Naval Aircraft.

He was promoted to Rear Admiral in November, 1943, and appointed Deputy and Assistant Chief of the Bureau of Aeronautics. In addition to the duties of this key position, he served as Navy member on various boards and committees, including the N.A.C.A., the Aircraft Production Board, the Joint (Army-Navy-British) Aircraft Committee, and the New Weapons Committee of the Joint Chiefs of Staff.

In 1946 he retired from the Navy to enter the aircraft industry.

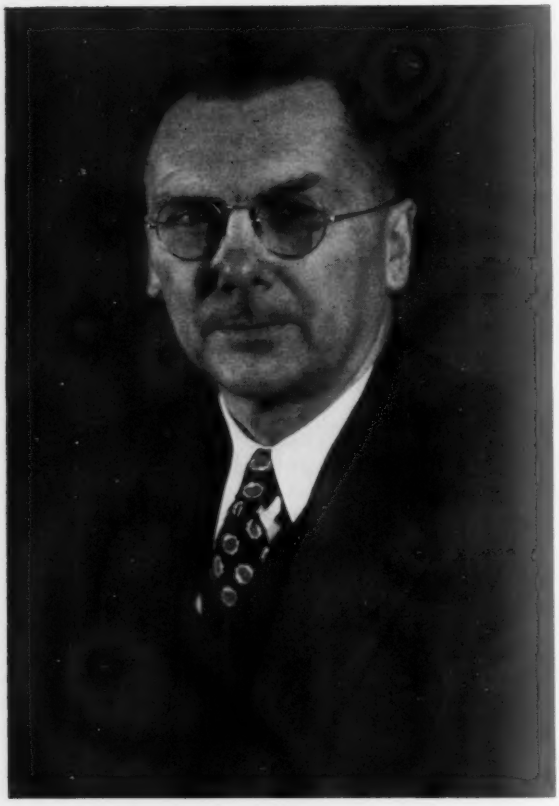
Admiral Richardson was awarded the Legion of Merit by the U.S. Navy in February, 1946. He is a Commander of the Order of the British Empire, the appointment being made for services as Senior Naval Member, Joint Aircraft Committee.

(*See photo, page 12*)

## *National Meetings Calendar*

| | |
|---|---|
| **December 16** | Wright Brothers Lecture, Washington, D.C. |
| **Jan. 29–31, Feb. 1, 1951** | Nineteenth Annual Meeting, New York |
| **March 16, 1951** | Flight Propulsion Meeting, Cleveland |

# 1950 Guggenheim Medalist



Dr. Hugh Latimer Dryden

*. . . "outstanding leadership in aeronautical research and fundamental contributions to aeronautical science."*

The selection of Hugh Latimer Dryden, Director, N.A.C.A., as the recipient of the Daniel Guggenheim Award for 1950 has been announced jointly by the American Society of Mechanical Engineers, the Institute of the Aeronautical Sciences, and the Society of Automotive Engineers. The presentation will take place on January 29, 1951, at the I.A.S. Honors Night Dinner at the Hotel Astor in New York.

Dr. Dryden was chosen as this year's medalist for his "outstanding leadership in aeronautical research and fundamental contributions to aeronautical science." This was the unanimous decision of a 22-member board composed of former recipients of the medal and representatives of the three organizations. This signal American aeronautical honor is presented annually for notable achievement in the advancement of aeronautics.

Born in Pocomoke City, Md., on July 2, 1898, Dr. Dryden was educated at The Johns Hopkins University, receiving his B.A. degree in 1916, M.A. in 1918, and Ph.D. (Physics) in 1919. He began his aeronautical career as a Laboratory Assistant with the National Bureau of Standards. During his 19 years with the Bureau of Standards, he became Chief of the Aerodynamics Section, Chief of the Mechanics and Sound Division, and Associate Director. He was appointed to his present position as N.A.C.A.'s Director in 1947.

Among other honors that have been accorded Dr. Dryden are The Sylvanus Albert Reed Award for 1940 from the I.A.S., the Presidential Certificate of Merit, and America's second highest decoration for civilians, the Medal of Freedom. In 1938, he gave the Institute's annual Wright Brothers Lecture on the subject, "Turbulence and the Boundary Layer." He also delivered the Thirty-Seventh Wilbur Wright Memorial Lecture before The Royal Aeronautical Society in London in 1949. His subject on this occasion was "The Aeronautical Research Scene—Goals, Methods, and Accomplishments."

Dr. Dryden's work has been largely concerned with wind pressure on structures, turbulence in wind tunnels, properties of airfoils at high speeds, and boundary-layer investigations. He has authored various technical books and has contributed numerous articles, reports, and bulletins to scientific journals. He has been Editor of the JOURNAL OF THE AERONAUTICAL SCIENCES since 1941.

An Honorary Fellow and Past-President of the I.A.S., Dr. Dryden is also a Fellow of The Royal Aeronautical Society and is a member of the A.S.M.E., American Physical Society, and Washington Academy of Sciences. He is an Honorary Officer, Civil Division, Order of the British Empire.

## A.S.M.E. Organ Transfers Editorial Offices

Editorial responsibility for *Applied Mechanics Reviews* was transferred from the Illinois Institute of Technology to the Midwest Research Institute where Martin Goland, M.I.A.S., Chairman of its Engineering Mechanical Division, assumed editorship. This change was effective as of the October, 1950, issue.

*Applied Mechanics Reviews* is published by The American Society of Mechanical Engineers in cooperation with the following organizations: Office of Air Research, Midwest Research Institute, American Society of Civil Engineers, Institute of the Aeronautical Sciences, American Institute of Physics, American Mathematical Society, Society for Experimental Stress Analysis, The Engineering Institute of Canada, and The Institution of Mechanical Engineers (Great Britain).

## University of Illinois To Give Written Exams for Commercial Pilot Certificate

According to an announcement issued by the University of Illinois, that institution became the first school in the nation authorized to administer written examinations for the commercial pilot certificate.

To qualify for a commercial pilot license, a candidate must pass a flight test and a written examination in aircraft and engines, meteorology, navigation, and Civil Air Regulations. The University of Illinois' chief pilot, Jesse Stonecipher, has been authorized by the C.A.A. to give the flight tests; Robert W. Johnson, in charge of the ground school, will administer the written examinations.

## CalTech Honors Pioneer

California Institute of Technology paid tribute to one of aviation's pioneers, Albert A. Merrill, Instructor in Aeronautics, when a new subsonic wind tunnel on the Institute's campus was dedicated to him in an informal ceremony on August 31.

About 50 guests, representing industrial and educational research organizations, were present to hear Dr. Lee A.

# 1950 Wright Trophy Winner

Grover Loening was selected as this year's recipient of the Wright Brothers Memorial Trophy, which will be presented to him at the Wright Memorial Dinner to be held in Washington, D.C., on December 16. The award, which was established 3 years ago by the National Aeronautic Association, is given for "significant public service of enduring value to aviation in the United States." It was given previously to W. F. Durand, H.F.I.A.S., and Charles A. Lindbergh, F.I.A.S.

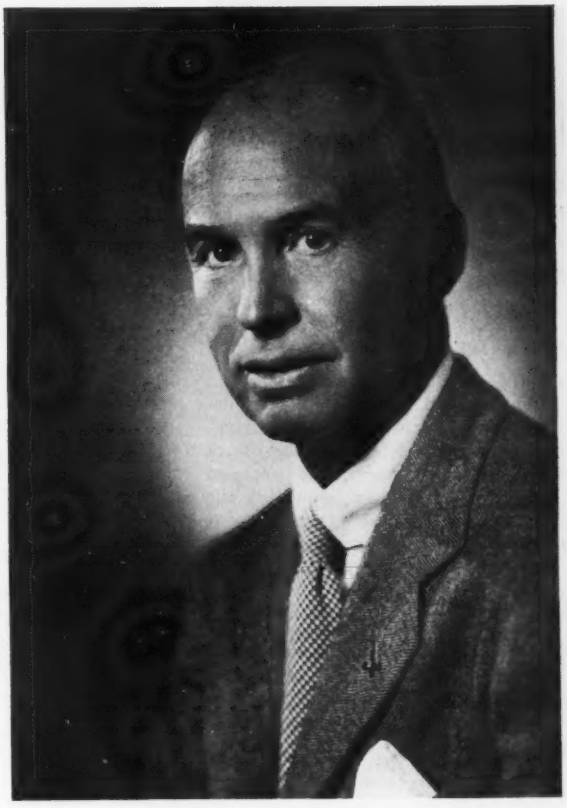
Throughout his career, Mr. Loening has consistently demonstrated his devotion to the advancement of aviation. This interest was apparent during his undergraduate days at Columbia University when he became one of the organizers of the Columbia University Aero Club in 1908 and its first Vice-President. In 1910, he submitted what is believed to be the first thesis ever written on the subject of modern aeronautics. His paper was entitled "Practice and Theory of Aviation."

Since those days Mr. Loening has been constantly associated with aeronautics. He learned to fly in 1911 and holds Private Pilot Certificate No. 2648. He was the first civilian aeronautical engineer with the U.S. Army Signal Corps during World War I, prior to which time he had been General Manager of the Wright Brothers' airplane plant in Dayton, Ohio. Subsequently, he has served with approximately half-a-dozen aviation manufacturing concerns, has designed airplanes, and has headed his own companies.

In the last 13 years Mr. Loening has been associated with various governmental agencies. These include his being Aeronautical Advisor, U.S. Maritime Commission; Consultant on Aircraft, War Production Board; Chairman, Helicopter Committee and Aeronautical Consultant, N.A.C.A.; Member of the Board, National Air Museum of the Smithsonian Institution; and Consulting Specialist, President's Air Policy Commission.

Many honors have been accorded Mr. Loening since his days at Columbia. Among them are the Wright Trophy, the Collier Trophy, the Distinguished Service Award, Columbia University's Medal of Honor, the Egleston Medal of Columbia University, and the President's Medal of Merit.

Mr. Loening is a Founder, Fellow, Benefactor, and Past-Officer of the I.A.S., as well as a member of the I.A.S. Advisory and Aeronautical Archives committees. In addition, he is also a Fellow of The Royal Aeronautical Society of Great Britain and a member of the Society of Automotive Engineers. He helped found the Aeronautical Chamber of Commerce in 1922 and served as its first President.



**Grover Loening**

***. . . "significant public service of enduring value to aviation in the United States."***

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DuBridge, CalTech's President, introduce Dr. Clark B. Millikan, Director of Guggenheim Aeronautical Laboratory, CalTech, who told of Mr. Merrill's many contributions to the field of Aeronautics.

The wind tunnel, now officially named the "Merrill Tunnel," is approximately 110 ft. long and has a 32- by 45-in. test section, which can handle models with a wing span up to 40 in. Power is supplied by a 75-hp. electric motor with a three-bladed fan. The tunnel's speed of 0 to better than 175 m.p.h. is attained through control of the pitch of the fan blades. It will have a balance system capable of handling six component forces. The Merrill Tunnel, which will be used for student instruction and commercial testing, follows an original design of Mr. Merrill's. He served as consultant during its final design and construction by Aerolab Development Company.

Albert Merrill is probably the oldest living intimate of many of aviation's early notables. Toward the close of the last century, he did aeronautical research for S. P. Langley on the problem of locating the center-of-pressure travel on a curved surface in a natural wind. In 1895, he helped found the Boston Aeronautical Society with Octave Chanute as its first president. He carried on an active correspondence with Wilbur Wright and received from him a letter, written 2 days after the Wrights' first powered flight, which described just what had been done and what their hopes were.

At his high-school commencement address in 1892, Mr. Merrill predicted that man would be able to fly in small ships with light powerful engines within 10 or 15 years. In the years since then, he has made countless scientific tests and studies and has to his credit numerous practical developments, inventions, and patents.

Among these can be found a number of "firsts" including (1) the building of the first Hanging Wire Balance for aeronautical work; (2) the construction of the first U.S. wind tunnel at the Massachusetts Institute of Technology in 1896; (3) the publication of the first paper on lift of curved surfaces in the July, 1899, issue of the *British Aeronautical Journal;* (4) the patenting of his "Up Only" aileron;

Albert A. Merrill.

(5) the invention and first use of an "open-air wind tunnel"; (6) the development of the first meniscus, moving-tube micromanometer; (7) the use of flexing members for frictionless joints on a wind-tunnel balance; and (8) the proving of the reversal of the movement of the center of pressure as the angle of attack of a curved surface varies from 0 to 90°.

Mr. Merrill was unable to attend the dedication ceremonies because of ill health. However, he did hear them from his home over the telephone, while Mrs. Merrill officially represented him on the campus.

### JOINS FAIRCHILD

*Walter Tydon (M.) was appointed Chief of Design Engineering, Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation. A veteran aircraft designer with 24 years' experience in the aviation industry, Mr. Tydon was formerly associated with the Airplane Division of Curtiss-Wright Corporation as Chief Design Engineer. During World War II, he was Chief Engineer at the Curtiss Buffalo plant in charge of P-40 and C-46 design.*

# News of Members

▸ **Giuseppe Bellanca** (F.), President, Bellanca Aircraft Corporation, was awarded a scroll by the Aero Club of Washington in recognition of his 42 years of work in the field of aviation development.

▸ **Colonel Humberto Delgado** (M.), Portugal, was elected Second Vice-President of the Council of the International Civil Aviation Organization for a term of 1 year.

▸ **Lawrence G. Fritz** (M.), Vice-President-Operations, American Airlines System, has taken a 3-month leave of absence as of October 1.

▸ **Dr. Paul Emil Hemke** (A.F.), Faculty Dean and Head, Aeronautical Engineering Department, Rensselaer Polytechnic Institute, has been elected to the Board of Trustees, Green Mountain Junior College.

▸ **Earl D. Osborn** (A.M.), Founder and retiring President, Edo Corporation, was elected to the newly created position of Chairman of the Board.

▸ **Dr. William R. Sears** (F.), Director, Graduate School of Aeronautical Engineering, Cornell University, received an outstanding achievement medal awarded by the University of Minnesota to certain distinguished alumni of its Institute of Technology. It was presented at an alumni dinner on October 5.

▸ **Dr. Hector R. Skifter** (M.), President, Airborne Instruments Laboratory, Inc., was appointed in September to the chairmanship of the Committee on Navigation, Research and Development Board, Department of Defense. Dr. Skifter had served as Acting Chairman for the 6 months prior to this appointment.

▸ **Rear Admiral Paul A. Smith,** U.S.C. & G.S. (A.F.), was elected First Vice-President of the Council of the International Civil Aviation Organization for a 1-year term.

▸ **Norman L. Winter** (M.), Assistant to the Vice-President and General Sales Manager, Sperry Gyroscope Company, was appointed a member of the Committee on Navigation, Research and Development Board, Department of Defense.

▸ **Colonel Clarence M. Young** (M.), Vice-President (San Francisco), Pan American World Airways, Inc., was appointed by Governor Earl Warren to California's Civil Defense Utilities Committee as the Northern California representative for air transportation.

## *Members on the Move*

**This section has been instituted to give information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.**

**Calvin J. Abel** (T.M.), Aerodynamicist "B," Engineering Department, Consolidated Vultee Aircraft Corporation. Formerly, Electrical Installer, Convair.

**Thomas Barish** (M.), Consulting Engineer, 3210 Warrensville Center Rd., Shaker Heights, Cleveland 22. Formerly, in Washington, D.C.

**Edward S. Carter, Jr.** (T.M.), Graduate Student, Massachusetts Institute of Technology. Formerly, Vibration Engineer, Sikorsky Aircraft Division, United Aircraft Corporation.

**Private Dean R. Commer,** A.F.N. 17200062 (T.M.), 3512th Maintenance Squadron, Randolph Air Force Base, Tex. Formerly, Field Service Mechanic, Consolidated Vultee Aircraft Corporation.

**Kachas Derdiarian** (T.M.), Standards Analyst "A," Lockheed Aircraft Corporation. Formerly, Assistant Standards Supervisor, Pan American World Airways, Inc.

**Richard G. Fledderman** (M.), Associate Professor, Aeronautical Engineering, Georgia Institute of Technology. Formerly, Research Associate and Ph.D. Candidate, University of Michigan.

**M. J. Frank** (M.), Chief Structural Engineer, Aircraft Armaments, Inc. Formerly, Chief of Laboratories, Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation.

### SPECIAL ASSISTANT

*William A. M. Burden, Member, Benefactor, and I.A.S. Past-President, Partner, William A. M. Burden & Company, was appointed a Special Assistant to the Secretary of the Air Force, Thomas K. Finletter.*

**Walter J. Geudtner, Jr.** (T.M.), Aerodynamics Section, Engineering Department, Consolidated Vultee Aircraft Corporation. Formerly, Student.

**Lieutenant George R. Gillespie** (T.M.), Headquarters Far East Air Force, F.E.A.F. Base, Tokyo, Japan. Formerly, U.S.A.F. Institute of Technology, Wright-Patterson Air Force Base, Ohio.

**John R. Griffin, Jr.** (M.), Petroleum Chemicals Division, E. I. du Pont de Nemours & Company. Formerly, Chief Engineer, Research Laboratory, The Sharples Corporation.

**James R. Henry** (T.M.), Assistant Stress Analyst, McDonnell Aircraft Corporation. Formerly, Graduate Student.

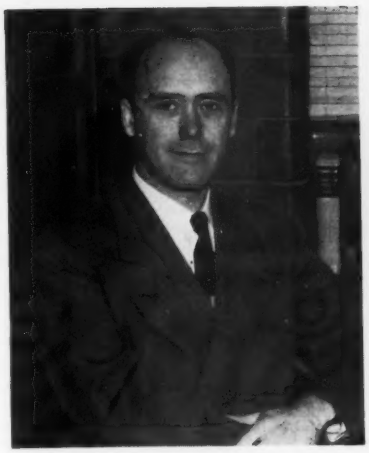
**George N. Jones, Jr.** (T.M.), now Engineering Aide GS-5, Naval Proving Ground, Va.

**Felix Kallis** (A.F.), GS-11 Aeronautical Engineer, Power Plant, Jet Engines, Overhaul and Repair Department, U.S. Naval Air Station, San Diego, Calif. Formerly, Jet Engine Test Engineer, Ryan Aeronautical Company.

**R. J. Kellner** (M.), Chief Engineer, Grand Central Aircraft Company. Formerly, Assistant Chief Engineer, Cal-Aero Technical Institute.

**Norbert H. Klein** (T.M.), Weight Engineer, Kellett Aircraft Corporation. Formerly, Instructor (Aircraft and Engines), Martinsburg Aircraft Service, Martinsburg, W.Va.

**Donald A. Liebel** (T.M.), Stress Analyst, Aerophysics Department, North American Aviation, Inc. Formerly, Student.



**PROFESSORSHIP**

*Dr. Frederick W. Ross (M.) has become Professor of Aeronautical Engineering at the University of Detroit. Previously, he was Head of Aerodynamics Research, Aeronautical Research Center, University of Michigan. Dr. Ross's experience has covered extensive aerodynamics research and development and flight testing on a wide variety of aircraft, large and small, fast and slow, and conventional and unconventional. Among his many contributions in the fields of aerodynamics and physics are aerodynamics in high-speed wind-tunnel research and design, improvements in supersonic experimental methods, and precision determination of the viscosity of air.*

**Captain Clayton C. Marcy,** U.S.N. (M.), now Chief, Production Branch, Industrial College of the Armed Forces.

**Andrew R. Marshall** (T.M.), now Junior Aeronautical Engineer, Missiles Group, Consolidated Vultee Aircraft Corporation.

**Colin H. McIntosh** (M.), Vice-President-Operations, All American Airlines, Inc. Formerly, Director, Operating Division, All American.

**Adolph Howard Meyers** (T.M.), Mechanical Engineer, Design Engineering Department, M. W. Kellogg Company. Formerly, Student.

**Dr. Ing. Angelo Miele** (M.), Professor of Mechanics, Escuela de Aviación, and Assistant Professor, Aerodynamic Design, Escuela Superior de Aerotécnica, Córdoba, Argentina. Formerly, Senior Project Engineer, Instituto Aerotécnico, Córdoba.

**Wayne E. Parriott** (T.M.), The RAND Corporation. Formerly, Aerodynamicist, Ordnance Research #1, University of Chicago.

**Kenneth Razak** (T.M.), Acting Dean, College of Business Administration and Industry, University of Wichita. Formerly, Director, School of Engineering, University of Wichita.

**Edgar P. Rhodes** (M.), Engineering Manager, Bell Aircraft Corporation. Formerly, Assistant to Chief Executive Engineer, Bell Aircraft.

**George H. Scragg** (M.), George H. Scragg Organization, now at 743 E. 82nd St., Cleveland.

**David R. Shoults** (A.F.), Director of Engineering, ARO, Inc. Formerly, Engineering Consultant.

# Corporate Members News

• **Aeroproducts Division, General Motors Corporation** . . . What is believed to be the world's first supersonic propeller "Spin Pit" will be in operation early in 1951. The pit designed to accomplish various mechanical tests upon supersonic propellers is a steel cylinder 12 ft. 10 in. in diameter and 7 ft. 10 in. high. It is sunk below ground level and is secured with an airtight seal to a concrete base. A steel dome is removable to provide installation and removal of the supersonic propellers. The chamber will be evacuated of atmosphere by a vacuum pump to 0.01 atmosphere, which will permit the use of a low horsepower (450-hp. R985) engine to rotate the propeller at a relatively high r.p.m.

• **AiResearch Manufacturing Company, Division of The Garret Corporation** . . . The first portable ground heater to be powered by a gas-turbine engine was delivered recently to the U.S.A.F. It is designed to produce 4,000,000 B.t.u. per hour on a −65°F. day and to warm up a six-engine B-36 within 15 min. in the subzero temperature of an Arctic winter.

• **Allison Division, General Motors Corporation** . . . Allison has announced that it is the first engine manufacturer to receive C.A.A. approval for commercial transport operation of both a centrifugal compressor turbojet and an axial-flow compressor turbojet aircraft engine. An Approved Type Certificate was issued on September 14 for Model 450-D4, an axial-flow turbojet engine. A centrifugal-type turbojet, Model 400-C4, was certified in May, 1948.

• **Aluminum Company of America** . . . A redesigned blow torch in which heavy-gage Alcoa Aluminum replaces traditional heavier metals for the tank was recently announced by Otto Bernz Company, Inc. This torch weighs only slightly more than 2 lbs.

• **American Steel & Wire Company** . . . Hyco-Span Aircraft Cable that expands and contracts at approximately the same rate as aluminum has been marketed. With a coefficient of expansion about 80 per cent that of 24ST aluminum, this steel aircraft control cable incorporates other advantages, according to the company. These are its nonmagnetic properties, its corrosion resistance, and a more simplified rigging with more positive control. It is claimed that the cable has no tendency to change from austenitic to ferritic steel under normal control tension loads. Tensile strength is slightly less than that of carbon or stainless steels. The difference in breaking strength varies with the size of the cable. The U.S.A.F. evaluation is included in a report titled "Hyco-Span, a High Expansion Aircraft Control Cable." The report is numbered MCREXA-45324-307 and is dated February 17, 1950.

• **Bell Aircraft Corporation** . . . The X-1, the first airplane to fly faster than sound, was turned over to the Smithsonian Institution, where it will be kept on permanent exhibit. This event took place at the Fourth Annual Convention of the Air Force Association.

• **Boeing Airplane Company** . . . The first of three Stratofreighter "Command Transports" was delivered in September to the Strategic Air Command Headquarters for use as a flying-headquarters transport. The new ships, known as VC-97D's, will be assigned to S.A.C. headquarters units for fast, long-range transportation of key staff personnel accompanying overseas missions. The VC-97D is completely fitted out as a mobile advance-base headquarters airplane, with complete living facilities for staff personnel.

• **Cessna Aircraft Company** . . . The real estate and equipment of Aero Parts Manufacturing Company, Inc., Wichita, was purchased at a public sale.

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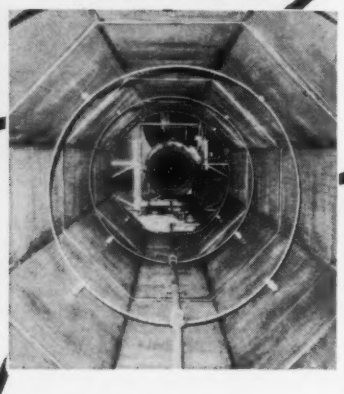

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INDUSTRIAL SOUND CONTROL

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• **Chance Vought Aircraft Division, United Aircraft Corporation** . . . A subcontract was received from Boeing Airplane Company for tooling and fabrication of major components of the Boeing B-47 jet bomber. Previously, another subcontract had been received from Lockheed Aircraft Corporation for P2V patrol-bomber component fabrication.

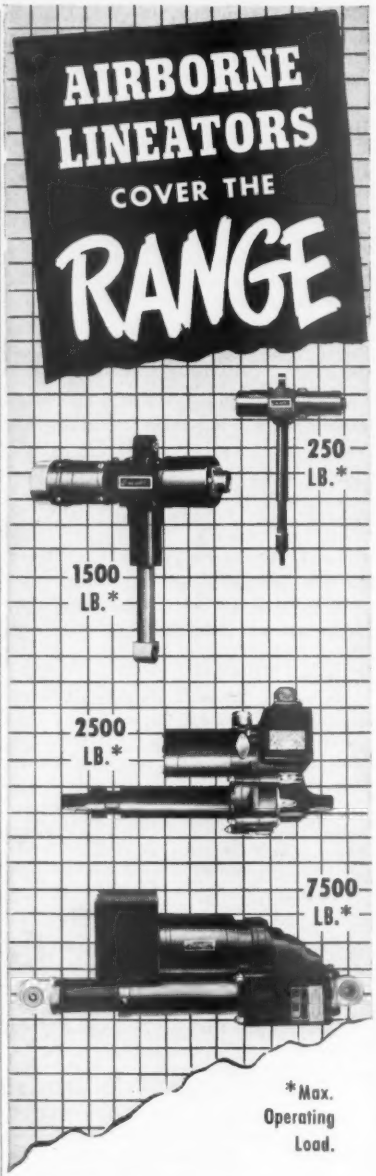
• **Curtiss-Wright Corporation** . . . The voluntary discontinuance of air-frame manufacturing at the Navy-owned Columbus Aircraft Division Plant was announced in September by the Corporation. It was stated that Curtiss-Wright acted in accord with a policy adopted some months ago when the company launched a program of concentration upon its principal business of designing and manufacturing of power plants, propellers, and flight simulators.

• **Eastern Air Lines, Inc.** . . . Capt. Eddie Rickenbacker, President and General Manager, announced that the company has arranged a $30,000,000 5-year bank credit with a group of 27 banks. The group is headed by The Chase National Bank of the City of New York. The loan agreement is based on $30,000,000 being made available over a 2-year period, and evidenced by revolving credit notes bearing interest at $2^1/_4$ per cent with a $^1/_4$ of 1 per cent commitment fee applying to the unused balance. At the end of the 2-year period, the agreement provides for an interest rate of $2^1/_2$ per cent and the repayment of the loan over the following 3 years in twelve equal quarterly installments.

• **General Electric Company** . . . Patents, name, and technical data of the Turbodyne Corporation, a research subsidiary of Northrop Aircraft, Inc., was recently purchased by G-E. Turbodyne Corporation has developed a turboprop aircraft engine believed to be the most powerful propeller-type aircraft power plant in the world . . . A redesigned line of thermocouple vacuum gages for industrial, laboratory, and other applications where vacuum must be accurately measured has been announced by the Meter and Instrument Division. Included in the line are a 115-volt a.c. portable gage and types for both rack and panel mounting. The gages give a continuous indication of pressure, which can be read directly from a scale calibrated from 0–200 microns . . . Bulletin GEA-5528, entitled "Extra Power Thru Turbosupercharging," is available to selected personnel in the aviation industry.

• **Lockheed Aircraft Corporation** . . . A 38-ft. Maxim Silencer of the resonance type has successfully completed tests and will be used to deaden the noise of the afterburner-equipped F-94's in ground runups. Attached to the tailpipe of the plane during the runup, the device is a steel cylinder that encloses a smaller perforated steel tube with metal wool stuffed in the space between. Sprays of water from a 6-in. main cool and slow the roaring blast by converting the noise into heat, which escapes through a vertical vent in the form of steam. The silencer was designed by Lockheed's engineering staff.

AIRBORNE LINEATORS COVER THE RANGE

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• **McDonnell Aircraft Corporation** . . . A noise-suppression program is under way at a cost of approximately $80,000. Already installed as a heat-dissipation device is a blast fence that consists of steel columns and wood, coated with a fire-resistant paint. Several noise-suppression chambers are scheduled to follow . . . Sales for the 1950 fiscal year totaled $38,688,383, and work performed (sales plus work in process) amounted to $40,608,253. On these sales the earnings after taxes were $2,815,219, equal to $8.25 per common share after the regular dividend on preferred stock.

• **Pan American World Airways, Inc.** . . . The sale of the assets of American Overseas Airlines to Pan American was consummated on September 25 when a check for $17,450,000 was turned over by Pan American. The sale included 18 aircraft, which, added to Pan American's fleet, bring the total airplanes now under Pan American's aegis to 144 Clippers of all types. In order to provide maintenance facilities for the additional aircraft acquired from A.O.A., the Overhaul Base at Miami is being expanded at a cost of more than $200,000 . . . Eighteen Douglas DC-6B's have been purchased at a cost of approximately $21,000,000 for delivery beginning in the fall of 1951. The transport will be powered by four Pratt & Whitney R2800-CB-17 engines, yielding a total of 10,000 hp. Hamilton Standard hydromatic reversing propellers will be used . . . The familiar "blackboard" bearing flight information written in chalk is being replaced at all P.A.A. terminals in Latin America by new schedule boards. The new, larger boards, 6½ ft. long, have interchangeable block letters and numerals, which are more legible. Each board is surmounted by a big electric clock . . . During the months of October and November, Pan American sponsored a sales contest among the personnel of its Latin American Division, its affiliated carriers, and travel agents in Latin America. The contest is designed to stimulate tourist travel and flow of air cargo between the United States and Latin America during a normally slack period. Similar local contests were to be held in Venezuela and Cuba.

• **The Parker Appliance Company** . . . Synthetic Rubber Products Company, Los Angeles, has been licensed to mold seals, gaskets, diaphragms, and other parts from approved synthetic rubber compounds specifically developed by Parker for aircraft hydraulic and aviation fuel systems. Synthetic Rubber Products will also distribute the complete line of Parker O-rings.

• **Piasecki Helicopter Corporation** . . . A building expansion program has been announced by the company. This program, together with the leasing of additional facilities, will provide a 175 per cent increase in plant area over that available a year ago.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation** . . . The Ford Motor Company is scheduled to build P. & W. engines, Model 4360, at the Ford Aircraft Engine plant, formerly known as the Dodge-Chicago plant. This 28-cylinder engine powers, among others, the B-36. Under the licensor-licensee program fostered by the Industrial Planning Division, A.M.C., Pratt & Whitney will provide Ford with technical and manufacturing data, as well as technical assistance in the preliminaries to production, and Ford will have complete responsibility for the operation of the plant . . . Formal control of its former wartime plant at Southington, Conn., was reassumed at Midnight, September 30. The 661,000 sq.ft. plant is to be operated as a satellite for the manufacture of engine parts to feed assembly operations in the East Hartford plant.

**THRUST-MEASURING STAND**

*The F-89 Scorpion, manufactured by Northrop Aircraft, Inc., is shown blasting out with all the power of its twin jet engines as technicians obtain accurate power calibration measurements on the universal thrust measuring stand at Edwards Air Force Base, Calif. Capable of measuring the forward thrust of all types of U.S. military aircraft—from the smallest to the largest—the thrust stand was built for the U.S.A.F. by the engineering division at Edwards A.F.B. A Northrop engineering group headed by Edward C. Denzin, M.I.A.S., Project Engineer, provided detailed design of the unique testing stand without cost to the Air Force. Thrust readings are obtained by mounting the airplane rigidly on "floating" tables and running the engines.*

• **A. V. Roe Canada Limited** . . . A combined igniter-fuel injector with improved starting qualities for combustion systems is under development. An igniter and an auxiliary injection jet are mounted centrally in the baffle by which the vaporizer tubes are supported. By this construction a flame from the auxiliary jet is provided for "lighting up." This flame will play on the vaporizer tubes, furnishing the heat necessary to vaporize the fuel before the normal combustion and self-vaporizing process has started. Once started, the process is self-sustaining, and the igniter and auxiliary jet may be turned off.

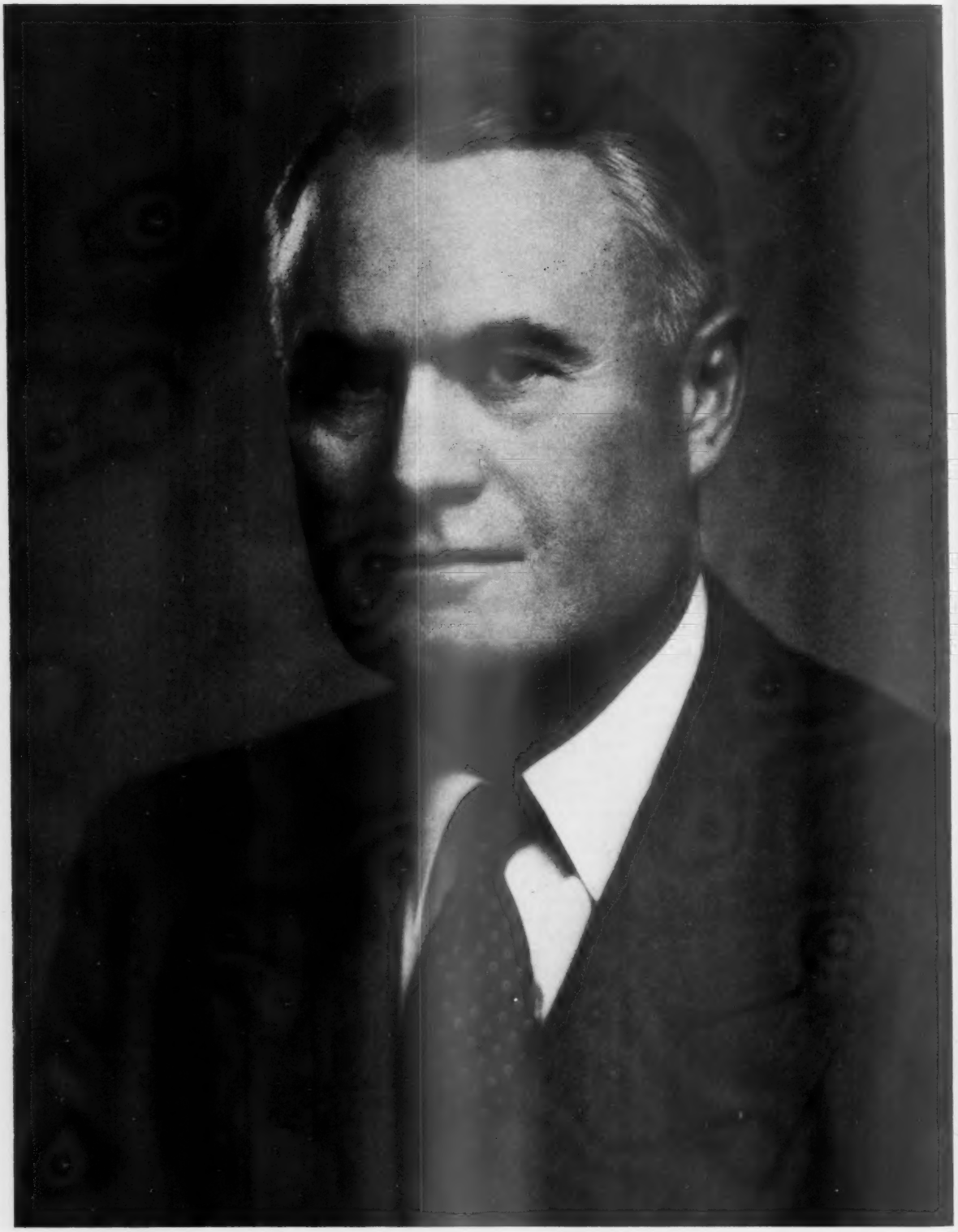
• **Ryan Aeronautical Company** . . . The Super 260 Navion is coming off the assembly line as a 1951 model.

• **Stratos Corporation, subsidiary of Fairchild Engine and Airplane Corporation** . . . Effective October 2, the corporate name of Stratos Corporation was changed to Stratos Division, Fairchild Engine and Airplane Corporation . . . Deliveries to Pan American World Airways of the Model S60-5A supercharger have begun. According to present plans, the superchargers are to be installed in Pan American's 049 Constellation fleet . . . Stratos air-conditioning equipment has been installed in the second prototype Douglas XA2D-1 turboprop Navy attack bomber.

• **Tinnerman Products, Inc.** . . . The new $2,000,000 Cleveland plant was formally opened on September 23. The old plant is scheduled to be reopened sometime before the end of 1950.

• **Wright Aeronautical Corporation, Division of Curtiss-Wright Corporation** . . . A long-term contract has been entered with Britain's Armstrong Siddeley Motors, Ltd., subsidiary of Hawker Siddeley Group. The agreement provides for a complete exchange of research and technical information and covers a license for the immediate building in the United States not only of the Sapphire jet engine but also of the Python, Double Mamba, and Mamba turboprop engines. The Sapphire is believed to be the world's most powerful jet engine and is rated at 7,200 lbs. static thrust for a dry weight of 2,500 lbs. Britain's most powerful turboprop is the Python, with a flight-test rating of 4,000 hp.

(*I.A.S. News continued on page 84*)



**L. B. Richardson, 1951 I.A.S. President-Elect**

(See page 5 for story)

# Editorial

## I.A.S. Fellowship

This time each year we receive occasional comment from our membership with reference to the selection of Fellows in the Institute. Although it is not too widespread, enough comes to our attention to indicate that some misconceptions exist with regard to the process whereby I.A.S. Fellows are selected—and why.

No one has ever come out flat-footed with the theory that elections are "rigged" for the benefit of any individual or group, but it is occasionally implied that sinister influences are at work which give the "long-haired" an advantage over the "shorts"—or vice versa. "How come," ask some, that Dr. Laminar F. Aerodynamics gets recognized when his boss, H. W. Manager (obviously a better man than Dr. L. F. A., or he woudn't be the boss!) is passed over? "How come," ask others, that workers in Governmental vineyards always get preference over the Busy Bees of industry?—and so on.

First, let's look at the record to see whether such complaints are justified.

From the list of American Fellows published in the JOURNAL for June, 1950, an analysis of their connections shows:

| | |
|---|---|
| From Aircraft Industry | 84 |
| From Universities | 35 |
| From Government Research | 27 |
| From Military Services | 16 |
| From Miscellaneous Unclassified | 7 |
| Total | 169 |

It is obvious that half of the total is on the industry side of the picture. Unfortunately, there is no easy way (statistically) of measuring the length of the hairs of the individuals involved. Possibly the "long hairs" tend to read more papers at meetings and gain more kudos than the "shorts." On the other hand, there are avenues for recognition open to the "shorts" which are not generally traveled by their more academic brethren. It looks to us like a "toss-up." From these figures, there thus appears to be little evidence of bias one way or the other.

Now, who are these people, and how did they get that way?

The By-Laws of the Institute specify that a candidate shall have "attained a position of distinction in aeronautics" and shall have "made notable and valuable contributions in one of the aeronautical sciences or in aeronautical engineering."

Further, a candidate "shall have been an Associate Fellow for one year or more." This is an absolute requirement. Again, let us remind you that there is no automatic promotion in the Institute to Associate Fellow. Each member in a lower grade *must apply* for advancement to Associate Fellow. There are many on our roster who have never taken that step, although they are unquestionably qualified. Only by becoming Associate Fellows can they become eligible for Fellowship, and they must see to that themselves.

As to method of election, the By-Laws have this to say:

> "Fellows shall be proposed and elected by the Honorary Fellows and the Fellows residing in the United States. *A favorable vote of three-fourths of those voting shall be required for election.*"

Every year the Secretary sends to the Fellows the complete roster of all Associate Fellows then eligible, asking for nominations "from the floor" as it were. *All* those nominated are put on the First Ballot, and the Fellows are asked to vote for not more than ten. The results are tabulated, and the high men go on the Second Ballot. This process of elimination is repeated at least once more in a Third Ballot. Only those who make the required three-fourths of the votes on the final round are elected.

[Two footnotes: (1) All balloting is strictly secret. Even the Secretary does not know who votes for whom. (2) In the past 4 years, between 130 and 150 Fellows have voted in each election. No minority group has dominated the balloting.]

Adding it all up, it is safe to say that few elections of any kind are more equitable or less susceptible of control than the election of I.A.S. Fellows.

In view of the occasional criticism, a great deal of thought has gone into ways and means of selecting Fellows. So far, no one has come up with any method that is better than the one we use. It appears to be democratic and foolproof. The Council would welcome suggestions, however, as to changes that might be made. Our first objective, however, must always be to maintain Fellowship in the I.A.S. the high honor that it is.

S. P. J.

# Performance Measurements of a Soaring Bird

AUGUST RASPET*
*Mississippi State College*

FIG. 1. The author in the "Kirby Kite," bird flight sailplane.

## INTRODUCTION

THE HISTORY OF AVIATION is intimately connected with the bird flight studies of early researchers. The mythical flights of Icarus and Daedalus on wings fashioned of wax and feathers represent our earliest recorded thinking about human flight. The flight of Daedalus from Crete to Sicily even today would represent a record-breaking motorless flight were it an actuality. The influence of da Vinci's studies of bird flight is apparent in his design. It is a prone-piloted ornithopter with scallopped monoplane wing surfaces. As the knowledge of flight accumulated, there was an increased effort on the part of those striving to fly to understand natural flight. In the nineteenth century, men such as Lilienthal, Marey, Langley, and Huffaker made important contributions to the understanding of the elements of natural flight. At the beginning of the present century, two students of natural flight, Hankin and Idrac, were able to continue their studies of flight despite the disrupting influence of the airplane.

Early efforts in bird flight research were confined to a close observation of the birds. A more refined approach was that of Marey, who developed a time-lapse camera that could be called the first movie camera. With this camera he was able to make models of the bird in a complete cycle of a wing flap. Langley also used a photographic technique with a stereoscopic pair of cameras. His studies, as well as those of his associate Huffaker, were confined to the soaring flight.

There is no doubt that an understanding of soaring flight should precede attempts at understanding the more complicated flapping flight. Soaring enthusiasts might have profited considerably in their development of the art and science of soaring flight had they maintained a closer liaison with the bird flight students. As an example of a possible contribution of this sort, one merely needs to read Huffaker's[1] paper written in 1897 in which he describes fully and accurately the method of thermal soaring as used by the turkey buzzards (Cathartes aura) around Washington, D.C. It was not until 1932 that thermal soaring was first practiced by man. Another example is that of dynamic soaring, the basis for which was propounded by Lord Rayleigh when he stated that soaring flight required either a wind that is not horizontal or which is not uniform in velocity. The utilization of the latter is, of course, dynamic soaring, which has not yet been accomplished in a controlled experiment by man. It is hoped in this paper to show how bird flight research on soaring birds can lead to an understanding of dynamic soaring.

## BACKGROUND DATA

The present study began in 1945 with an experiment in which a bird was trained by George F. Carter to carry a miniature barograph and recording anemometer. It was hoped to measure the performance of the bird as he glided between upcurrents. The method would have been subjected to errors because of the lack of knowledge on the strength of the downdrafts between the upcurrents. Unfortunately, no data were obtained by this method, for the bird died prematurely of an intestinal stoppage. Mr. Carter later offered to train a

Presented at the meeting of the Organization Scientific et Technical du Vol a' Voile at Örebro, Sweden, July 3–16, 1950.

* Engineering and Industrial Research Station.

buzzard to fly in a wind tunnel. By this technique the errors due to downdrafts would not be included in the performance measurements. It would also permit a detailed study of the wing tip slots such as land soaring birds possess.

In 1946 the author accidentally flew with some sea gulls on a ridge. It occurred to him that the performance of the birds could be obtained by a comparison with the sailplane's performance. The results shown in this paper were the result of a continuation of the first flight with the sea gulls.

## Discussion

For bird flight performance measurements one requires a slow-speed sailplane of good or exceptional maneuverability. Unfortunately, the trend in modern sailplane design is headed toward fast sailplanes. Fig. 1 is a photograph of the sailplane used in the current studies. It is an English-built "Kirby Kite." Its performance curve or calibration curve as it is used in this work is shown in Fig. 2. Examination of Fig. 1 shows the radio antenna mounted in the nose of the fuselage. Installed on the windshield is a Leica camera with a telephoto lens and a special optical viewfinder that permits determining the range of the bird.

Conditions ideal for collecting bird data are merely those ideal for thermal soaring. The crew for such measurements consists of three people, a pilot and two ground assistants. They go to the airport when thermal conditions are good and tow the sailplane to 300 m. with an automobile. The pilot begins soaring while the ground observers scan the sky for birds. As soon as one is spotted soaring within reach of the sailplane, the pilot is directed by radio to the bird. When the sailplanist sees the bird, he begins reporting the air speed and relative altitude of the bird with respect to the sailplane. The pilot attempts to adjust his rate of turn and turn radius to agree with that of the bird. Also, during this soaring phase the pilot reports the shape of the bird's wing. The buzzards normally have their wingtip slots open when soaring (gaining altitude). After the bird and sailplane have gained sufficient altitude for the bird's immediate purpose, the bird will strike out on a cross-country jaunt, taking a fairly definite heading. He closes his tip slots and cruises at speeds up to 30 m. per sec. During this cross-country flight, the sailplane pilot may follow as closely as 5 m. behind and below the bird. He is thus able to see the bird's control motions, to anticipate maneuvers, and to photograph the wing configuration at close range. During this phase of flight the bird is usually not aware of the sailplane. However, if the pilot speaks too loudly into his radio microphone or if the controls on the sailplane make a noise, the bird immediately notices the sailplane and attempts an evasive maneuver. During this tracking the pilot sends to the ground observers the air speed, relative altitude of the bird above or below the horizon, and the wing configuration at closely spaced time intervals. These data are recorded on the ground as a function of time and are later recorded as a tracking curve, Fig. 3. From portions of this curve where the bird is in constant speed flight for at least 1 min., the slope of the relative altitude curve is taken as the difference in sinking speed between the bird and sailplane. The sailplane's sinking speed is known from the calibration curve, Fig. 2, and thus the bird's sinking speed can be obtained since the difference is known. A series of such trackings will yield a speed polar for the bird in gliding flight. Similarly, the data taken during the soaring phase may be plotted and the speed polar in soaring flight so obtained. It should be mentioned that in the soaring phase, circling flight, no corrections were made for the increased sinking speed of the sailplane or bird due to centrifugal loading. The angles of bank used by both the sailplane and bird were usually less than 30°. Another assumption made in these measurements is that the bird and sailplane are influenced equally by vertical air motions in the atmosphere. Whether this is a valid assumption will be resolved by an independent experiment in which a captured bird will be taken up in a two-place sailplane at dawn when the air is stable. The bird will be released from the two-place sailplane while in slow flight so as not to disturb the bird. The measuring sailplane towed up at the same time will be ready to track the released bird and to make measurements in the still air. Whether the bird will cooperate

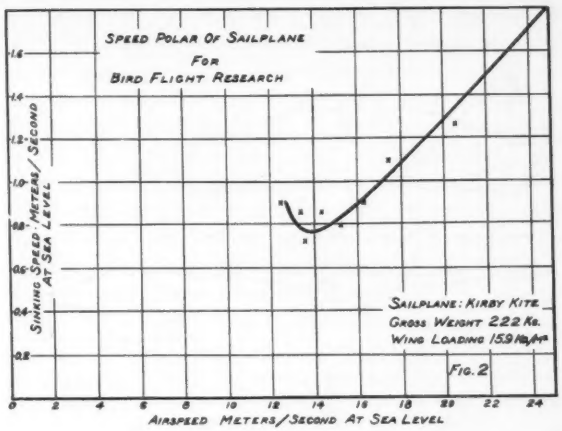


Fig. 2

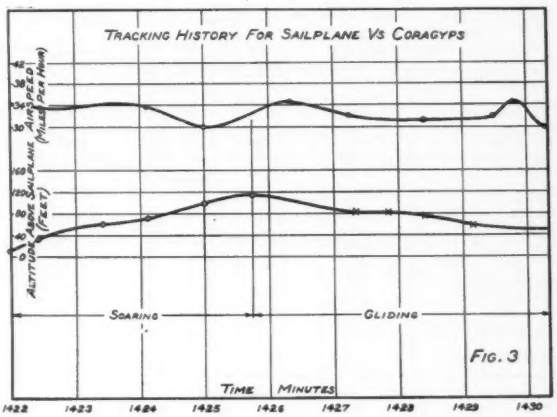


Fig. 3

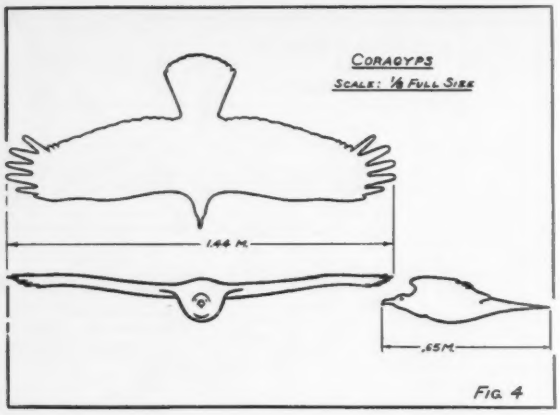


FIG. 4

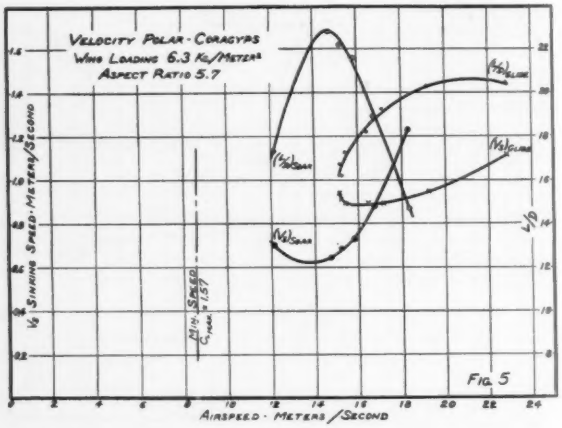


FIG. 5

in this experiment or simply dive to the lower warmer surface is yet to be determined.

On many occasions birds come to join the sailplane in a particularly good thermal. This makes it easy for the pilot to select a bird for measurement. It is evident from this behavior that the birds are not disturbed by the sailplane and that the results obtained closely approximate those in natural flight. The advantage of the silent flight of the sailplane is apparent in such research as this.

Following the usual sailplane practice, there is shown in Fig. 4 the three-view or general arrangement of the aircraft under consideration in this paper. The bird is commonly called a black buzzard or, scientifically, Coragyps atratus. He is an excellent soarer, though not so good as the turkey buzzard (Cathartes aura). However, the Coragyps happened to be plentiful in the autumn skies during the time the research was made. Fortunately, the Coragyps is also 30 per cent heavier in wing loading than the Cathartes. He is therefore easier to track with the sailplane used for this research. Since the sailplane had a wing loading nearly 2.5 times that of Coragyps, he had a distinct advantage in maneuverability over the sailplane. Because of this, any evasive tactics of the bird were completely successful.

In Fig. 5 are shown the measurements obtained by means of the sailplane tracking a number of different black buzzards. There may have been variations between one bird and the next, but in these results the data are treated as a statistical average representation of the bird's aerodynamics. The wing loading and aspect ratio shown are also averages obtained by numerous ornithologists. The captured bird technique may be an improvement in this respect, since the specimen (flight-test article) can be weighed at take-off and also measured for its geometry. Inspection of Fig. 5 shows that there are two distinct speed polars for the bird's two phases, soaring and gliding. The vertical velocity curve for the soaring phase appears similar to that of conventional sailplanes. However, the gliding phase curve has a much flatter polar. This is particularly evident if one views the gliding ratio curves. In sailplane terminology the bird would be said to possess a good speed range when gliding.

There are a number of other points which merit emphasis: the extremely low minimum sinking speed of the bird in soaring flight and the low speed at which he can fly. If one computes the power required for the bird to sustain level flight at a speed of 13.8 m. per sec., one finds the phenomenally low value of 0.019 hp. for a bird weighing 2.3 kg. This value corresponds to a power loading of 122 kg. per hp. The lowest soaring speed, 8.5 m. per sec., was determined by timing the bird around a complete circle and measuring the diameter of the circle in terms of the known wing span of the bird. The lift coefficient at this speed is 1.57, a relatively large value considering the Reynolds Number at which this lift occurs—namely, 140,000.

If the same data shown in Fig. 5 are plotted in terms of the nondimensional coefficients of lift and drag, there results the so-called drag polar, Fig. 6. In this polar the lift coefficient is plotted as the square, so that the drag polar (normally a parabola) is linearized. The reason for the bird's closing his tip feathers for gliding flight is immediately apparent from this plot. He does this to reduce his drag. With slots open he could not attain a lower drag coefficient than 0.012, but with the slots closed he can reach a minimum of 0.0058 in drag coefficient. It is also clear that the closing of the tip slots reduces the effective aspect ratio. At high speeds (low lift coefficients) the bird already has a low induced drag

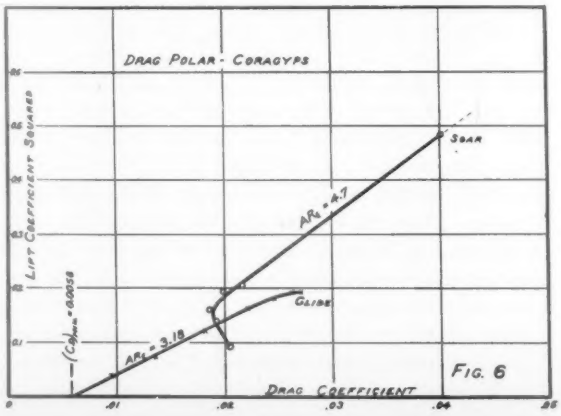


FIG. 6

and strives rather to reduce his parasite drag. Actual measurements of the induced drag and, consequently, the effective aspect ratio can best be done at lift coefficients much higher than those measured here. There is still left to be investigated the region from $0.7 < C_L < 1.57$. On the drag polar, Fig. 6, this represents a region three times more extensive than that shown. For this purpose a specially designed low-speed sailplane is required, one that can soar at 8.5 m. per sec. and has a wing loading of not over 7.0 kg. per sq. m. This low wing loading would also ensure good maneuverability provided the controls were properly designed for low-speed operation.

With such a research sailplane it will be possible to investigate accurately the flight of birds near their stalling lift coefficient. Some preliminary results obtained by extrapolation indicate that the Cathartes can utilize his wing tips as diffusors so as to attain an effective aspect ratio greater than his geometric. This means, in essence, that this bird may be controlling the flow beyond his wing tips or that he is extracting some energy from the wing-tip vortex. The delineation of this effect awaits the low-speed measurements. The very fact that the Coragyps is able, even at comparatively low lift coefficients, to control his effective aspect ratio is evidence that there should be expected even larger effects at the high coefficients.

The low minimum drag coefficient, 0.0058, becomes all the more interesting when one compares this with that obtained by some of the cleanest modern aircraft. The lowest measured drag coefficient that has been published is that of the Lippisch designed ME 163, which was 0.010. To explain the paradoxically low drag of the Coragyps, the drag coefficient based on total wetted area was computed and found to be 0.0020. The Reynolds Number of the highest measured speed of this bird is $4.4 \times 10^5$. At this Reynolds Number, the drag coefficient of a flat plate in laminar flow is 0.0021. Comparing this value with that of the Coragyps leads one to conclude that the bird must be able to control the flow over his body and wing so that it is laminar over its entire surface. How he does this can only be suspected. Victor Lougheed claimed that bird's feathers possess an asymmetrical porosity according to the direction of flow. He stated that a measurement shows the ratio of porosities to be 10:1. If this is true, then we must suspect the birds of having priority on suction through a porous surface as a boundary-layer-control means.

This paper is intended to show how powerful a research tool the sailplane becomes when applied to bird flight studies. The results reported, while precise as measurements to $\pm 5$ per cent, may not be truly representative of the static aerodynamics of the bird. He may, after all, be extracting energy from the atmospheric turbulence. If it is found by measurements in still air that a good portion of the energy for the bird's flight comes from this source, then it will have been established that dynamic soaring is really practiced by birds and that man must learn from them the mechanism.

From these measurements on the Coragyps, it was shown that this bird is able to fly with an extremely small expenditure of energy. His power loading at minimum power required was found to be 122 kg. per hp. It has been found by biophysicists that 45 kg. of animal muscle is able to deliver 1 hp. for several hours. These two values represent the power required and the power available. If man could devise a flying machine utilizing the fine aerodynamic principles of a bird yet weighing, together with the power plant (man), not over 122 kg. and if 45 kg. of muscle could be brought to work, then the dream of da Vinci would become a reality. The energy balance is established by these measurements; when the mechanism is better understood, then and only then will man fly.

It is the author's good fortune to have the encouraging support in this work of Dr. Harold Flinsch, Director of the Engineering Research Station. To the skillful bird tracking by Richard H. Johnson, the author attributes the precision of these measurements. The author owes a debt of gratitude to him and to Fred Obarr, who might have been soaring had he not volunteered his help on the ground.

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# Turbojet Afterburning Without an Afterburner

by Dr. Heinz E. Schmitt*
Wright-Patterson Air Force Base

### Abstract

The ideal afterburner should neither add too much weight nor diminish the power and efficiency of the standard engine under normal operating conditions.

To avoid any drag inducing installations in the tailpipe and to achieve a stable combustion in spite of the high velocity of the exhaust gases, the fuel is injected before the turbine nozzles, the turbine wheel being used as a flameholder. Because of the natural ignition delay, the fuel does not burn until it has passed through the turbine wheel.

It is concluded that, if the diffuser section and the burner section are united as one, simplicity and high efficiency with a minimum of space and weight requirements can be attained. This would result in the saving of a considerable amount of strategic materials.

### Purpose

Preliminary test work and study have been made for the purpose of using a method of afterburning where the fuel is injected before the turbine nozzles, thus eliminating flameholders, etc.

### Scope

The scope of this investigation has been limited to tests on the German turbojet Jumo 004, in which this method was applied first, and to tests on three American jet engines of later design with higher turbine discharge velocities.

### Summary

Afterburning is feasible without a tailpipe combustor simply by injecting fuel ahead of the turbine nozzles. No artificial drag-inducing installations are necessary, and the tailpipe can be kept relatively short. The minimum diameter and, consequently, the area of the tailpipe are determined by the Mach Number of the gas velocity in the pipe, Mach Number 1 being the limit beyond which no heat can be added in a steady process. The Mach Number before the temperature rise in turn determines the temperature ratio of the afterburning in a constant area tailpipe. For instance, an initial Mach Number of 0.4 allows a temperature ratio of approximately 2, which, with the present turbine temperatures of 1,250°F., means an afterburning temperature of 3,040°F. (3,500°R.). With such a tailpipe of constant area that requires only minimum space, 30 to 32 per cent thrust increase can be expected. An afterburning tailpipe, which is divergent in such manner that the temperature ratio is proportional to the ratio of the areas, would produce 45–50 per cent thrust boost. An efficient diffuser, however, involves considerable length and volume, while an increase in area in a short distance involves an appreciable loss of energy. Therefore, it will always be necessary to compromise between the two extremes mentioned. With the "ahead of the turbine injection" method, which does not require flameholders, etc., it is possible to unite the diffuser section and the burner section into one. *During the afterburning the diffuser efficiency will be increased as the gases are accelerated rather than decelerated.* This makes it possible to combine simplicity with high efficiency and a minimum of space and weight requirement.

Tests with three contemporary engines were made at A.M.C. Power Plant Laboratory. The results are compared, and theoretical relations are presented mainly as a function of the Mach Numbers.

Engine No. 1 was equipped with a 26-in. tailpipe, 8 ft. long, and a clamshell-type variable nozzle. The annular turbine exhaust area was increased 1.5 times. Thrust increase of 25 per cent could be obtained with fuel consumption only 7 per cent above the theoretical.

Engine No. 2, equipped with a short standard tail cone and nozzle 37 in. long and constant area, produced 22 per cent thrust increase with fuel consumption 32 per cent above theoretical, while the 67-in. long standard tail cone and nozzle produced the same thrust with fuel consumption only 15 per cent above theoretical.

Engine No. 3, equipped with a diffuser flameholder-type afterburner 29 in. in diameter, 12 ft. long, and annular exhaust area increased 1.9 times, produced 33 per cent thrust increase based on the engine with nonoperating afterburner but only 22 per cent based on standard equipped engine running with the same turbine exhaust temperature. This is the only correct way of comparison. The fuel consumption was then 100 per cent above theoretical.

The series of tests performed shows that this method described (uniting diffuser and burning sections by injecting the fuel before the turbine) possesses merits that can make afterburning much more practical than it is at present. These tests were made with modest means, but it is hoped that this report offers enough information to stimulate further work on an expanded basis.

### Symbols

| | |
|---|---|
| $F.C._a$ | = additional fuel consumption for afterburning, lbs. per hour |
| $F.C._b$ | = fuel consumption (basic), lbs. per hour |
| $F_j$ | = thrust without afterburner, lbs. |
| $F_{ja}$ | = thrust with afterburner, lbs. |
| $F_{jai}$ | = thrust with afterburner with divergent tailpipe |
| $T$ | = static temperature, °R. |
| $T_t$ | = stagnation temperature (total), °R. |
| $C_p$ | = specific heat, B.t.u./(lb.)/ (°F.) |
| $M$ | = Mach Number |
| $P$ | = static pressure, lbs. per sq.ft. |
| $A$ | = area, sq.ft. |
| $\gamma$ | = ratio of specific heat |
| $\rho$ | = mass density, lbs.-sec.$^2$/ft.$^4$ |
| $g$ | = acceleration of gravity, ft./sec.$^2$ |
| $R$ | = gas constant, ft./lb. (lb.) (°F.) |
| $w$ | = velocity, ft. per sec. |
| $v$ | = specific volume, cu.ft. per lb. |

* Air Materiel Command, U.S.A.F.

$\eta$ = ratio of thrust with a constant area tailpipe to a divergent tailpipe

$Z$ = ignition delay, sec.

*Subscripts*

0 = pertains to ambient conditions

1 = pertains to conditions before temperature rise

2 = pertains to conditions after temperature rise

## Introduction

Analysis has shown that afterburning is the most practical method presently known for producing thrust augmentation in turbojets and can be used over a wide range of conditions. However, in spite of the simplicity of the basic idea, it is still in the experimental stage, more or less, even after 10 years of otherwise vigorous development of turbojets. The ideal afterburner should neither add too much weight nor, on the other hand, diminish the power and efficiency of the standard engine under normal operating conditions.

It is possible to avoid drag-inducing installations in the exhaust tailpipe and still achieve a stable combustion, in spite of the high velocity of the exhaust gases, by injecting the fuel ahead of the turbine nozzles and using the turbine wheel as a flameholder. Because of the natural ignition delay, the fuel does not burn until it has passed through the turbine blades. The first successful application of this method was made with the German turbojet Jumo 004, which, as a matter of fact, was designed for afterburning from the very beginning in October, 1939, which explains the rather elaborate exhaust system of the Jumo 004. This afterburning combination was ready for mass production in the Spring of 1945. The first successful tests were made in 1942.

A series of tests on engines of the later designs containing higher turbine discharge velocities were made in the Power Plant Laboratory of the Air Materiel Command at Wright Field. The test results are compared and the theoretical foundation is presented.

A major problem encountered in afterburning is that of maintaining a stable and efficient combustion in a rapidly flowing gas stream. In modern turbojets the turbine discharge velocity (1,000 to 2,000 ft. per sec. = $M_1$ of 0.5–0.6) of the turbine seems high, but this will undoubtedly be increased inasmuch as the specific thrust per unit area is augmented with the increase of the mass flow. Higher pressure ratios may offset this effect but only where the increase in mass flow and temperature does not keep up with the engine development. The conventional method of assuring stable combustion in a rapidly flowing gas stream consists of utilizing a diffuser with flameholders of some type aft of the turbine wheel and is generally accompanied by an appreciable loss of energy. Though the same conditions apparently exist in the ram-jet, there are two major differences: (1) The air is already preheated, and (2) the turbine wheel in the turbojet serves as a most ideal flameholder. Because of the natural ignition delay,*

* ($Z = (K/p^n)e^{E/RT}$, Lloyd, Mullins, F. A. F. Schmidt.)

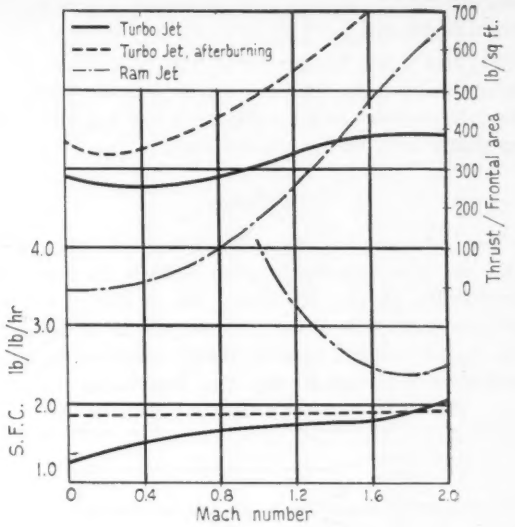



Fig. 1 Comparison between Ram Jet, Turbo Jet, and Turbo Jet with afterburning. 40,000 ft.

which may be 1/1,000 to 2/1,000 sec., it is possible to inject the fuel in front of the turbine nozzles, and the phase of combustion, which is connected with the temperature rise, occurs a few inches aft of the turbine wheel. The turbine nozzles, of course, function as atomizers in a manner similar to that of a common spray gun. Behind the turbine wheel, the ignition speed catches up with the velocity of the gases, and combustion ensues.

A number of tests with various modifications were conducted with two different types of turbojets in which it was proved that the principle actually works. In addition, reasonable combustion efficiencies were obtained. In more than 50 cycles of afterburning, each of 2- to 3-min. duration, the turbine wheel remained in good condition. This work represents only the logical application of our present knowledge. Engine No. 1 had a turbine discharge velocity of 1,150–1,200 ft. per sec. ($M_1$ = 0.58–0.6), while in Engine No. 2 the velocity was only 720 ft. per sec. ($M_1$ = 0.39–0.4). In the latter, stable combustion was achieved with a standard tail cone and nozzle not longer than 37 in. measured from the turbine wheel to the exhaust outlet.

The future aircraft designs will probably show a strong tendency toward sweptback wings, which will often require extremely short tailpipes. In this case, a short afterburner may become imperative if the combination of a turbojet with afterburning is to remain practical. Afterburning can more than double the output of a turbojet at supersonic flight speeds (Fig. 1). This should justify any efforts expended toward the development of the possibilities of afterburning. With the increase of the permissible operating temperature of the turbine blades, the effect of the afterburning decreases as less oxygen is left in the exhaust gas for this purpose. This makes it all the more important to avoid any interference with the standard performance of the engine. The maintenance of the flameholders

and fuel nozzles is then likely to become a serious additional problem.

Turbine blade temperatures that render the use of afterburning unnecessary are still remote; hence, in the interim it appears feasible to bridge this gap utilizing simple but effective afterburning.

## Testing

The test setup for Engine No. 1 was somewhat primitive but was apparently good enough to prove the workability of the principle. The standard (21 in.) tailpipe was replaced by an enlarged (26 in.) pipe of 9-ft. length, while a variable thrust nozzle of the clamshell type was added (Fig. 2). Provisions for extra

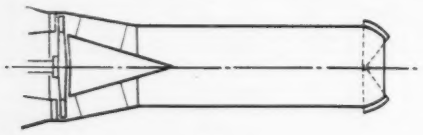


Fig. 2

cooling and insulating the tailpipe were not made. This restricted the temperatures and therewith the thrust boost to about 25 per cent. For comparison purposes, the needle type of the German Jumo 004 is shown in Fig. 3. Each of the combustion chambers was equipped

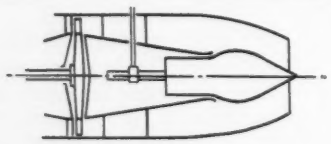


Fig. 3

with one additional fuel nozzle, which was located on the top of each chamber approximately $2^1/_2$ in. ahead of the turbine diaphragm. The fuel nozzles were the same as in the prime combustor and had the same flow characteristics. The inner liner was provided with a hole through which the fuel was injected, while the tip of the nozzle was positioned so that it was even with the liner in order to protect the nozzle against overheating during nonoperation.

The test procedure was as follows: The variable jet nozzle was closed to a position where standard thrust was obtained; then, additional fuel was injected simultaneously with the opening of the clamshell. The fuel flow and nozzle area were adjusted so that the main fuel flow and r.p.m. were maintained constant as they would have been under standard conditions. This created a somewhat difficult situation for the operators of both the afterburner and the engine, since it was impossible for them to see one another and they were compelled to communicate through a third person by means of hand signals. However, enough data were gathered for a mathematical evaluation.

The tests with Engine No. 2 were made in a test stand with excellent provisions for convenient operation and accurate measurements. In the first series of tests, standard tail cones without any alterations were used as shown in Figs. 4a and 4b. The long, as well as short, tail cones have the same diameters, and, since the change in area is small, it can be considered as constant. In the second series of tests, the tail-cone area was increased by cutting off part of the inner cone, as shown in Fig. 4c, and by adding a cylindrical section, as shown in Fig. 4d. A jet nozzle of fixed area was then placed directly on the cone. Three different sizes of jet nozzles were employed.

## Test Results

With the large nozzle, the No. 2 engine ran with an extremely low exhaust gas temperature, which averaged 680° to 700°F. without afterburning. In Fig. 5

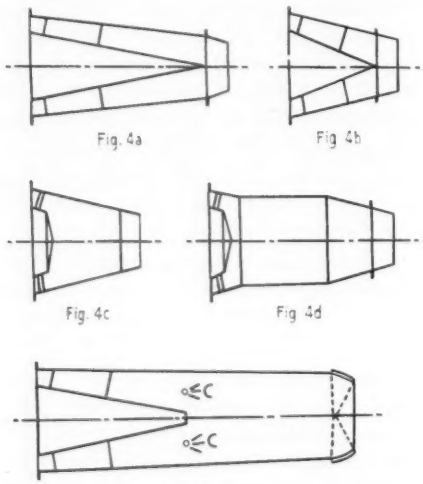


Fig. 4a Fig. 4b

Fig. 4c Fig. 4d

Fig. 4e

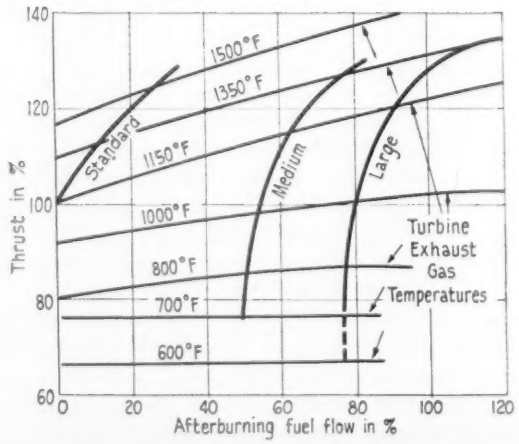



Fig. 5 Thrust versus Fuel Flow in % for various nozzle areas.

the thrust increase is plotted against the fuel consumption of the afterburner. These curves were obtained by varying the amount of fuel over a certain range, and, as the jet nozzle area is fixed, thrust and turbine exhaust temperature decreases with a decreasing amount of fuel and vice versa. Below 1,000°F. the combustion efficiency deteriorates rapidly, and, when approaching 800°F., the combustion becomes unstable and, finally, discontinues in spite of the relatively large amount of fuel still injected. This phenomenon is similar to that found in the Diesel engine in that a certain temperature must be attained before self-ignition can occur. In using the standard jet nozzle where the turbine exhaust temperatures are elevated to more than 1,150°F., it was found that afterburning could be started with a small amount of fuel and that a smooth increase in thrust could still be obtained. With the use of a variable thrust nozzle it proved possible to move along the temperature lines and maintain a good combustion efficiency over the entire range; however, this does not mean that a variable jet nozzle is necessary in every case. It is possible to start this kind of afterburning even with the large jet nozzle and low initial temperatures simply by injecting the proper amount of fuel and simultaneously accelerating the engine approximately 200–300 r.p.m.*

In Fig. 6 the thrust increase in percentage of the standard thrust is plotted against the fuel consumption in percentage of the basic fuel consumption of the engine. The heavily drawn curves represent what might be theoretically possible. Curve 1 is based on the assumption of a constant Mach Number and static pressure not affected by the temperature rise (which necessitates a divergent tailpipe), where

$$A_2/A_1 \cong \sqrt{T_2/T_1}$$

In this case

$$F_{ja}/F_j \cong \sqrt{T_2/T_1}$$

This simplification is not correct because of the variation in specific heat; however, the error is small. Thus, the equation for the fuel ratio can be expressed as

$$\frac{\text{F.C.}_a}{\text{F.C.}_b} = \left[\left(\frac{F_{ja}}{F_j}\right)^2 - 1\right]\left[\left(\frac{T_0}{T_1 - T_0}\right) + 1\right]\frac{c_{p2}}{c_{p1}}$$

While Curve 2 represents the case in which the area is constant, there is considerable change of velocity

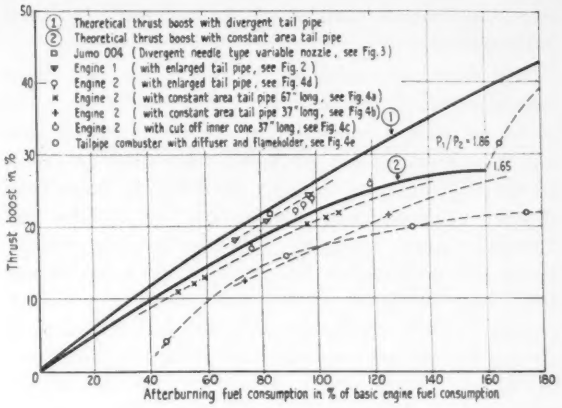

1 Theoretical thrust boost with divergent tail pipe
2 Theoretical thrust boost with constant area tail pipe
Jumo 004 (Divergent needle type variable nozzle, see Fig. 3)
Engine 1 (with enlarged tail pipe, see Fig. 2)
Engine 2 (with enlarged tail pipe, see Fig. 4d)
Engine 2 (with constant area tail pipe 67" long, see Fig. 4a)
Engine 2 (with constant area tail pipe 37" long, see Fig 4b)
Engine 2 (with cut off inner cone 37" long, see Fig. 4c)
Tailpipe combuster with diffuser and Flameholder, see Fig. 4e
$P_1/P_2 = 1.86$
1.65
Thrust boost in %
Afterburning fuel consumption in % of basic engine fuel consumption
0
10
20
30
40
50
20
40
60
80
100
120
140
160
180

Fig. 6 Thrust boost versus fuel consumption in %

and momentum in the pipe because of the rise in temperature, produced by the afterburning. (The mathematical correlations are shown later.) The various designated points were obtained from test data. The square point is for the old German Jumo 004, which was close to the theoretical line. The thrust increase was found to be 22 per cent. The turbine discharge velocity in this engine (Jumo 004) was extremely low (550 ft. per sec.) and the gas flow vortex free. The tailpipe was divergent $A_2/A_1 = 2$. Conditions were almost ideal for this kind of afterburning (Fig. 3). The triangles represent the results from Engine No. 1 with 1,150–1,200 ft. per sec. turbine discharge velocity which had a tailpipe with a ratio $A_2/A_1$ of approximately 1.5 (Fig. 2). The static thrust increase with this arrangement was 25 per cent, with a fuel consumption only 7 per cent above the theoretical. (Considering the fact that the clamshell-type variable nozzle used had no seal rings, which resulted in a perceptible leakage, combustion must have been excellent.) All the other points are obtained from Engine No. 2 with 720 ft. per sec. discharge velocity. Crossing the line for constant-area conditions, one sees a dashed curve marked by slanted crosses. This curve represents the data with an unaltered standard long tail cone (see Fig. 4a) which can be considered to have a constant area. The erect crosses represent the marks for a short standard tail cone (Fig. 4b). The difference in fuel consumption was mainly due to the fact that the combustion in the short tail cone was not so complete as that in the long one. The thrust increase for both was approximately 21 per cent. The points designated by circles (tail up) represent the data obtained with a short tail cone but cutoff innercone to gain on area (Fig. 4c). The remaining cap, which merely covered the disc of the turbine wheel, was supported only by four cylindrical rods of $^3/_4$ in. diameter. Engine No. 2 had a considerable vortex behind the turbine which was straightened out by guide vanes in the standard configuration. The omission of these vanes and the inner cone diminished the basic thrust 1–2 per cent. Since it is not certain which one of these two changes exerted more influ-

* NOTE: It is logical to assume that afterburning without variable-area thrust nozzles could be of some importance for guided missiles or similar aircraft developments where simplicity and economy are highly desirable. Fortunately, simplicity and high efficiency can be combined, for, as soon as higher turbine exhaust gas temperatures are attained (above 1,000°F.), ignition problems disappear. For example, injecting all the fuel necessary to raise the temperature in the tailpipe to 3,500°R. in a turbojet of present configuration would raise the turbine exhaust gas temperature from 1,250° to 2,200°F., which would be in the realm of air-cooled turbine blades. Such a power plant could propel an aircraft designed for a top speed of Mach Number 2 and still cruise at a Mach Number above 1.0 without afterburning at 1,250°F. turbine exhaust temperature.

ence, appropriate tests would be necessary to determine this fact.

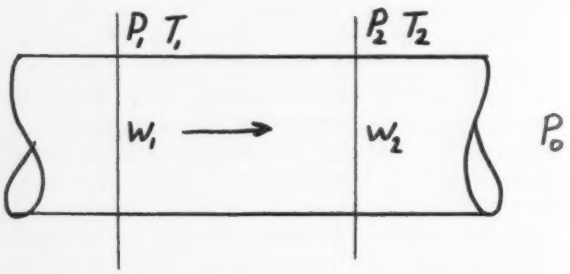
Unfortunately, these points cannot be used for a highly accurate comparison, since failure in the speed governor made it impossible to operate the engine with the same r.p.m. as was employed in the other test runs, its speed being approximately 50–60 r.p.m. lower than desired. Consequently, the airflow was smaller and naturally more favorable for afterburning. If the r.p.m. had been higher, the results would probably not have been so good. These tests could not be repeated at the time because the tailpipe was already altered for the next modification, which is illustrated in Fig. 4d. Since the area $A_2$ here was considerably increased, the ratio was $A_2/A_1 = 1.9$. The data obtained with this modification are marked by circles (tail down). Considering the fact that 2 per cent of the basic thrust was lost, approach to the theoretical line would have been close, but, since comparison is based on the standard output, this loss is carried by the afterburning. Thus, there was not more than 23–25 per cent thrust increase; however, consumption was lower than that presently obtained in the constant-area tail cones.

The next curve designated by circles represents the data obtained from a diffuser-type flameholder afterburner ($A_2/A_1 = 1.9$) (see Fig. 4e), which has a multitude of fuel nozzles and a clamshell-type variable jet nozzle. This afterburner is of considerable size and weight and interferes with basic performance of the basic engine, and, to produce the same standard thrust without afterburning, an increase of the turbine temperature is necessary to compensate for the losses. It is apparent that injection of more fuel would not produce any additional thrust except through increasing additional mass flow. A thrust boost of 22–23 per cent is the maximum if based on the thrust produced by the standard engine running with the same turbine temperature. This appears at present to be the only correct method of comparison.

### Theory of the Constant-Area Tailpipe

As noticed, the theoretical curve for the constant-area tailpipe also has a maximum, but the reason here is different: The temperature rise and pressure ratio are coupled. The curve is calculated for a static pressure ratio of 1.65 and $M_1 = 0.4$. The dashed curve branching off is the geometrical location of all maximums for the various pressure ratios above 1.65. For a pressure ratio of 1.86 and $M_2 = 1$, the temperature ratio reaches its maximum here with 1.9–2.

During flight, the pressure ratio increases by the ram effect, and the dashed curve asymptotically approaches Curve 1—i.e., the faster the speed, the higher the pressure ratio behind the turbine, the smaller the difference between the diffuser tailpipe and the constant-area tailpipe. In explanation of this particular phenomenon, the respective equations are presented as follows:




$$P_1 - P_2 = \rho_1 w_1 (w_2 - w_1) \quad (1)$$

$$\rho_1 w_1 = \rho_2 w_2 \quad (2)$$

$$Pv = RT \quad (3)$$

With these three equations it is possible by introducing the Mach Number to express

$$P_1/P_2 = (1 + \gamma_2 M_2^2)/(1 + \gamma_1 M_1^2) \quad (4)$$

$$\sqrt{T_{t2}/T_{t1}} = \frac{M_2 \sqrt{1 + \frac{\gamma_2 - 1}{2} M_2^2}/(1 + \gamma_2 M_2^2)}{M_1 \sqrt{1 + \frac{\gamma_1 - 1}{2} M_1^2}/(1 + \gamma_1 M_1^2)} \quad (5)$$

$$T = T_t/\{1 + [(\gamma - 1)/2]M^2\} \quad (6)$$

$$w = M\sqrt{gR\gamma T} \quad (7)$$

Utilizing Eqs. (6) and (7), it is possible to compute the actual jet velocity, and therewith the thrust, while Eq. (5) enables us to determine the fuel consumption and to plot combustion temperature of afterburning against turbine outlet temperature as depicted in Fig. 7, in which $T_{2t}$ is plotted against $T_{t1}$ for various values of $M_1$. $M_2$ is assumed to have its maximum value here, which is 1. At present, the usual temperature permitted for uncooled turbine blades is 1,710°R. For a $T_{t2}$ of 3,500°R., $M_1$ cannot be more than 0.4. The temperature ratio $T_{t2}/T_{t1} \cong 2$. A mean temperature of 3,500°R. is obtained with an excess of air, 1.2 to 1.25. It seems questionable if much higher temperatures are possible. Temperatures over 4,000°R. are not probable with liquid hydrocarbon fuels under the conditions prevailing in the tailpipe. In other words, with the present turbojets we cannot expect thrust augmentation above 42 to 50 per cent under static conditions. With increasing turbine-blade temperatures, the afterburning effect will decrease in percentage. Assuming an air-cooled turbine

blade for 2,000°R., the static thrust increase by afterburning would not be more than 30 per cent. This combination might be possible in the near future if efforts are directed properly, yielding twice the standard thrust at supersonic speeds.

Even if we had turbine blades that could withstand stoichiometric temperatures, there are a number of reasons that would make the aforementioned combination more practical. However, to expand or theorize on this phase is not within the scope of this report. In Fig. 8 it can be seen that the necessary pressure ratio is 1.86 with $M_1 = 0.4$ if $M_2$ should become 1. For Engine No. 2, $P_1/P_0 = 1.65$ with $M_2 = 0.88$. The temperature ratio does not change appreciably between $M_2 = 0.8$ and 1 according to Eq. (5). Fig. 9 shows the thrust ratio between the constant-area tailpipe and the diffuser type plotted over the pressure ratio.

$$\eta = F_{ja}/F_{jat}$$

By substitution, the following equation is obtained:

$$\eta^2 = \frac{2\frac{\gamma_2}{\gamma_2 - 1} R_2 T_2 \left[\left(\frac{P_0}{P_2}\right)^{(\gamma_2-1)/\gamma_2} - 1\right] + M_2^2 \gamma_2 R_2 T_2}{2\frac{\gamma_2}{\gamma_2 - 1} R_2 T_2 \left[\left(\frac{P_0}{P_1}\right)^{(\gamma_2-1)/\gamma_2} - 1\right] + M_1^2 \gamma_1 R_1 T_1}$$

$$\left(\frac{P_0}{P_2} = \frac{P_1}{P_2}\frac{P_0}{P_1}\right)$$

The equation can be presented in a family of curves $P_1/P_2$ as determined by Eq. (4) and $T_2/T_1$ by Eq. (5). Only two curves are drawn with $P_1/P_0 = 1.65$ and 1.86 and $M_1 = 0.4$ for both.

There are three significant points for each curve:

(1) With $M_1 = M_2$; $P_1/P_2 = 1$.

$$A_2/A_1 = \sqrt{T_2/T_1} \text{ and } \eta = 1$$

This point is common to all curves.

(2) With $M_1 > M_2$; $P_1/P_2 < 1$; $W_1/W_2 = 1$.

$$A_2/A_1 = T_2/T_1 \text{ and } \eta > 1$$

(3) With $M_1 < M_2$; $P_1/P_2 > 1$.

$$A_2/A_1 = 1 \text{ and } \eta < 1$$

For $A_2/A_1 = 1$ the maximum thrust increase is obtained if $p_1/p_0 = p_1/p_2$. With $p_1/p_2 = 1.86$, $M_2$ reaches its maximum value of 1. From there on, $p_1/p_0 > p_1/p_2$, and the curve that is obtained by connecting these points approaches 1 asymptotically with higher pressure ratios of $p_1/p_0$. For most of the present turbojets, the pressure ratio will become 1.86 and will increase with flight speed. As soon as $M_2$ exceeds 1, a divergent thrust nozzle would be beneficial, but with pressure ratios of $p_1/p_0$ below 5 the difference between a nondivergent and a divergent thrust nozzle is not more than 3 per cent. Hence, we can assume that, with increasing pressure ratio, the difference between the diffuser-type and the constant-area tailpipe becomes smaller. Of course, decreasing $M_1$ has the same effect.

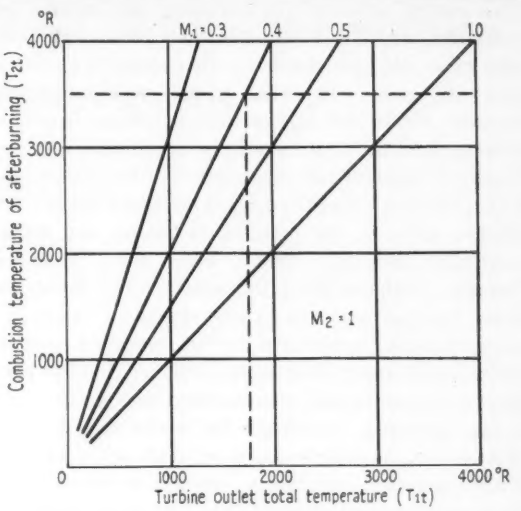



Fig. 7 Combustion temperature of afterburning versus Turbine outlet total temperature for various initial Mach numbers ($M_1$)

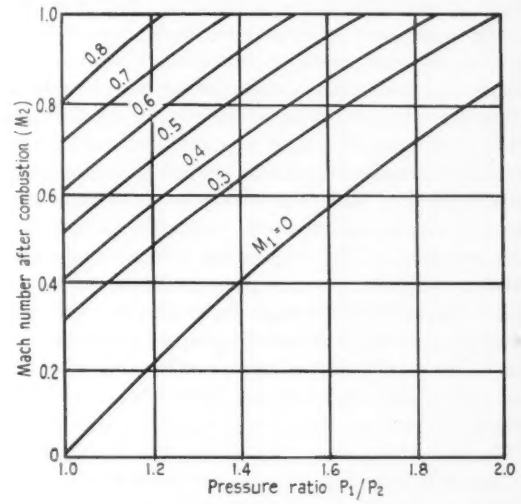



Fig. 8 Mach number after combustion ($M_2$) versus pressure ratio $P_1/P_2$ for various initial Mach numbers.

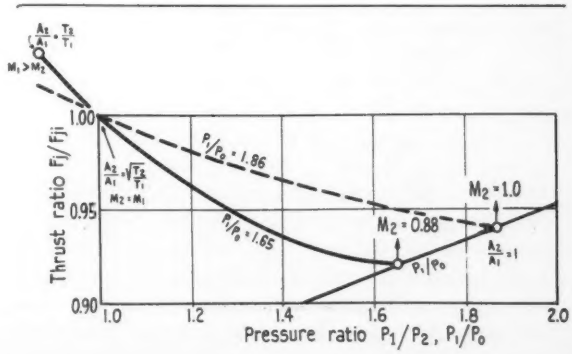



Fig. 9 Static Thrust ratio versus pressure ratio $P_1/P_2$, $P_1/P_0$.

This can be achieved by increasing the turbine temperatures, which in turn would also increase the pressure ratio, etc., provided no other changes on the engine are made. In other words, with supercritical pressure ratios and higher turbine temperatures, the tailpipe can be kept relatively small without sacrificing too much of the effectiveness of the afterburning if the injection before the turbine method is used. With smaller surfaces, the problem of cooling the walls is essentially lessened. On the other hand, a properly divergent tailpipe gives the same thrust boost with lower temperatures—i.e., some excess air is left over for cooling, or rather insulating, purposes, and the fuel could be injected in such a manner that the maximum temperatures are concentrated more to the center of the tailpipe. It should be mentioned, however, that, as soon as sonic speed is reached in the exit area of the exhaust gas nozzle, it is extremely desirable that combustion be completed, because at sonic speed heat cannot be added without creating severe pressure fluctuations, since this undesired combustion in the exit area or shortly before will never be a steady process. If it were a steady process, it could be easily remedied by readjusting the afterburning fuel flow or the nozzle exit area. Transition from deflagration to detonation is undesirable in turbojets and ram-jets. At present, not much is known about this phenomenon. However, where no combustible mixtures remain, there will be no detonation. As long as the heat release from combustion ensues at the fuel input rate, combustion will be steady and comparable to a Bunsen burner flame. The more complete combustion there is, the less probability will there be for the presence of combustible mixtures downstream from the burner sections. The unburned fuel mixtures are latent, and the energy can be released either as deflagration or detonation by any disturbances such as shock waves which may occur as soon as sonic speed is approached near the tailpipe outlet.

Consequently, not only from the standpoint of economy but with a view to minimize the undesired effects mentioned above, combustion should be as complete as possible before the gases leave the burner section.

To ascertain the best compromise for a practical design, the speed, range, and purpose of the aircraft must be considered. The analysis of these interrelations are not considered within the scope of this report, but the data presented here should prove helpful in initiating such an investigation.

## Conclusion

It is concluded that afterburning is feasible without a tailpipe combustor when fuel is injected ahead of the turbine nozzles, even at a gas velocity of 720 ft. per sec., corresponding to a Mach Number of 0.4, which is high compared to the gas velocities in the flameholder section of present afterburners. Simplicity with high efficiency and a minimum of space and weight requirements can be employed.

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# Design of a Device for Measurement of Free-Stream Static Pressure at Supersonic Speeds

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*University of Michigan*

## Introduction

The basic aerodynamic requirement for a device to measure free-stream static pressure is, of course, that the disturbances to the pressure field generated by the presence of the "body" of the device itself in the flow should be as small as possible in the vicinity of the pressure-sensing orifices on the body for all, or at least for the normal, conditions of operation. In the sequel, this basic requirement is analyzed in detail and decomposed into separate subsidiary requirements. Considerations of fundamental aerodynamic behavior of two- and three-dimensional bodies in subsonic and supersonic streams lead then logically to the design of a self-correcting device that meets most of the above requirements at supersonic speeds.

## Errors in Free-Stream Pressure Measurements and Corresponding Requirements

The separate requirements for the free-stream static pressure measuring instrument can best be formulated in terms of the various errors known to occur in such instruments. One can start with the consideration of an "ideal" position of the probe in a nonviscous flow at a given "design" speed. Even in such a case, an error—i.e., a difference of the pressure at the orifice(s) from that in free stream—generally occurs. At other speeds and attitudes in an actual (nonidealized) fluid, additional errors enter. Not all of these additional errors are independent; for instance, the effect of viscosity introduces little additional error on a conventional pitot-static tube except when the tube is at an angle of attack so that the boundary layer tends to flow toward the lee side of the probe. Similarly, the errors due to change of speed from the design speed and those due to the angle of attack are generally not mutually independent so that they cannot easily be corrected by a simple calibration procedure. The various separate requirements can be classified as follows:

(a) Minimum "basic" deviation of pressure at the orifice location from that in free stream in the *"ideal" case* defined above—i.e., in the case of potential flow around an ideally smooth probe at (usually) zero angle of attack and at a given "design" Mach Number.

(b) Minimum additional pressure deviation in the *actual case* of a probe with standard (production) roughness and shape deviation in the presence of a true fluid but with probe position and Mach Number as under (a). This requirement includes the suppression of effects of pressure orifice size and shape but primarily that of the boundary layer for zero angle of attack.

(c) Minimum additional pressure deviation caused by change of *angle of attack and yaw* in the ideal potential flow of case (a). This requirement implies the suppression of the effect of the flow field change due to probe attitude, as well as airplane attitude, known as "position error."

(d) Minimum additional pressure deviation caused by a change of *Mach Number* from the design Mach Number in the ideal potential flow of case (a). This requirement would essentially eliminate any Mach Number corrections for fixed probe and airplane attitudes encountered in wind tunnels.

(e) Minimum additional pressure deviation caused by the simultaneous effects of *viscosity, attitude, and Mach Number* [which were considered separately in requirements (b), (c), and (d)].

(f) *Minimum lag* in response in case of unsteady conditions. Satisfactory compliance with this dynamic requirement depends mostly upon the "internal arrangement" rather than the exterior characteristics of the device.

(g) Minimum errors due to the conversion of the pressure at the orifice into a "reading." This requirement on the internal mechanism of the instrument is common to all pressure-measuring instruments and has been dealt with extensively. Successful techniques for its satisfaction are known and therefore will not be discussed herein.

Finally, a requirement could be added which is not connected with the accuracy of the instrument:

(h) *Minimum drag* due to the measuring device. This aerodynamic requirement is related to another general requirement of *ease of installation*.

The above classification of the requirements has the advantage that the corresponding errors can, in general, be evaluated experimentally and/or theoretically except, perhaps, in case (e). In other words, one can compute and/or measure these errors and thereby calibrate the instrument. This possibility makes the requirements less stringent in character. However, the more of these requirements complied with, the more practical and useful the instrument; calibration curves can be used effectively for correcting the instrument

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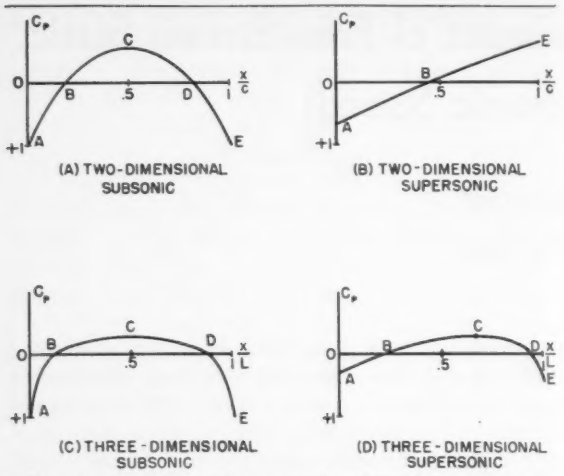


FIG. 1. Subsonic and supersonic schematic pressure distributions over a two- and three-dimensional body, having the same circular arc profile.

readings only when the additional variable causing the error (such as angle of attack, rate of change of pressure, etc.) is *simultaneously measured or known*. Aside of the disadvantages of the additional instrumentation needed for the determination of these variables, the successive application of more than one calibration curve entails excessive work and becomes impractical. In this sense, errors corresponding to (e) cannot be corrected for by calibration; a successful instrument must be essentially self-correcting with respect to these errors.

## General Aerodynamic Considerations

Simplicity demands that the body of the probe be essentially symmetrical.* One can consider three-dimensional axisymmetric bodies and two-dimensional airfoil-type bodies. The obstruction of these bodies to the flow creates local pressure and velocity fields; to satisfy requirement (a) pressure-sensing orifices should be located at positions on the body where the local pressure matches the pressure of the free stream. When a pressure coefficient diagram is available for the body, such positions are characterized by the zero value of the pressure coefficient (see points $B$ and $D$ in Fig. 1). Any streamlined body in subsonic or supersonic flow has at least one such station. Any body compresses the fluid in the neighborhood of its nose as it literally pushes the fluid out of its path. For a given body profile, the magnitude of the compression and the corresponding positive pressure coefficient depend upon the nature of the process—subsonic or supersonic, two-dimensional or three-dimensional. Schematic theoretical pressure distributions over a two-dimensional airfoil made up of two circular arcs and over a three-dimensional body formed by rotating these arcs about the longitudinal axis are shown in Fig. 1 for subsonic and supersonic flow at zero angle of attack. All of these bodies exhibit a region of compression (between points $A$ and $B$) but of various severity.

For three-dimensional bodies, the fluid moves out in all directions, whereas for two-dimensional bodies it can move out only upward or downward. As a consequence, the "two-dimensional compression" is more severe.† For instance, at Mach Number 2, the pressure coefficient on the surface of a cone with a 10° semivertex angle is 0.106, while on the surface of a two-dimensional wedge with a 10° semivertex angle it is 0.253. To achieve the same pressure coefficient two-dimensionally, a more pointed and slender wedge of semivertex angle 4.8° would have to be used.‡ A similar alleviation of compression occurs for three-dimensional case in subsonic flow. The fact that the pressures will deviate less from the free-stream pressure for three-dimensional than for two-dimensional bodies with the same length-to-thickness ratio is seen on Fig. 1: The pressure coefficient curves in (c) and (d) are shallower than in (a) and (b), yielding smaller absolute values of local pressure deviations.

The preceding comparisons of three-dimensional and two-dimensional effects at the nose of a body is of general interest but concerns the design of the device in question only insofar as it affects the location of the points $B$ and $D$ at which the free-stream pressure occurs. To understand this effect better, consider the current method of measuring free-stream pressure at supersonic speeds. Since points $B$ and $D$ on any three-dimensional body will shift with Mach Number and angle of attack [which fact would introduce errors corresponding to (c), (d), and (e)], a body made up of a conical nose and a long cylindrical section (inspired by the subsonic pitot-static tube) is used with the hope that the point $D$ will be fixed. This hope is relatively well born out in the ideal nonviscous case. Some 8 to

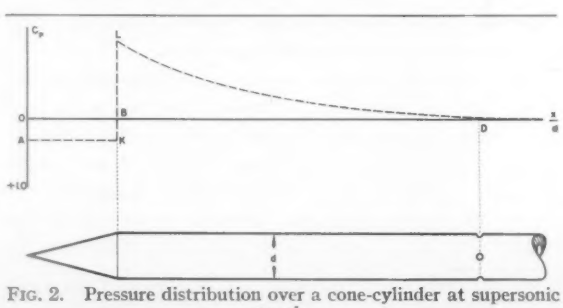

FIG. 2. Pressure distribution over a cone-cylinder at supersonic speeds.

* When unsymmetric probes (such as the one described on page 94 of *Elements of Aerodynamics of Supersonic Flows* by A. Ferri, Macmillan, 1949) are used, additional information about the orientation of the probe with respect to the stream must be available. This leads to additional complications of angle measurements and consequent additional errors.

† Another way of seeing this is in terms of the stream tubes. In three dimensions these form circular rings; to pass the same flux, the stream-tube thickness diminishes as the radius of the ring increases. Hence, in three dimensions, the outer stream lines are less curved and the overall pressure variation is less.

‡ This line of thought could be pursued further to show that at supersonic speeds a designer gains by using three-dimensional bodies to provide his design storage volume

10 diameter-lengths downstream from the cone-cylinder junction, the local pressure then is very nearly equal to that in the free stream (see Fig. 2). However, the necessity of having to place the pressure orifice relatively far downstream in a region of thickened boundary layer introduces undesirable sensitivity to viscous effects, especially at angles of attack when accumulation of boundary-layer air of low kinetic energy occurs on the lee side of the probe. Manifolding together four pressure orifices at extremities of perpendicular diameters (see Fig. 2) would correct satisfactorily for the angle-of-attack effect in an ideal fluid, but the boundary layer introduces undesirable errors.

The reader will ask the obvious question: Can't the static pressure orifice be obtained satisfactorily at the point $B$? The answer is in the negative for the three-dimensional probe. However, the clear understanding of the underlying reasons leads logically to a simple solution of the problem. In the cone-cylinder combination, the point $B$ actually does not move with Mach Number or angle of attack. Unfortunately, as one sees from Fig. 2, the pressure changes so fast at the shoulder that there is no hope of placing a pressure orifice there and getting anything but an average of pressures between points $K$ and $L$. If one uses an ogival shoulder, the location of the point $B$ becomes sensitive to the Mach Number.

A little consideration shows that the real difficulty lies in the fact that, immediately downstream of the shoulder where the local velocity is subject to no deviation from the direction of the free stream, its magnitude is considerably larger than the free-stream velocity and that therefore a large negative pressure coefficient results (point $L$). It is this effect that pushes the point $D$ far downstream; it is this effect that accounts for the large variations of pressure near the point $B$ and for its dependence upon Mach Number. The reason for the presence of this "overshooting" of the free-stream pressure at the shoulder, known as "overexpansion," is that the compression at the nose is three-dimensional and therefore relatively weak, while the expansion in going around the shoulder is essentially two-dimensional* and therefore stronger.

Having understood that the difficulty lies in the mismatching of the three-dimensional compression and the two-dimensional expansion, one proceeds to ask whether the mismatching is necessary. Since the turning of the shoulder will remain essentially two-dimensional no matter what is done, it is clear that the compression should also be made as nearly two-dimensional as possible. Fig. 3 represents two theoretically possible solutions: a two-dimensional airfoil and a hollow body obtained from the cone-cylinder combination by boring out a cylindrical hole. The latter scheme depends upon the questionable stability of the flow through the hole so that the first scheme should be given preference.

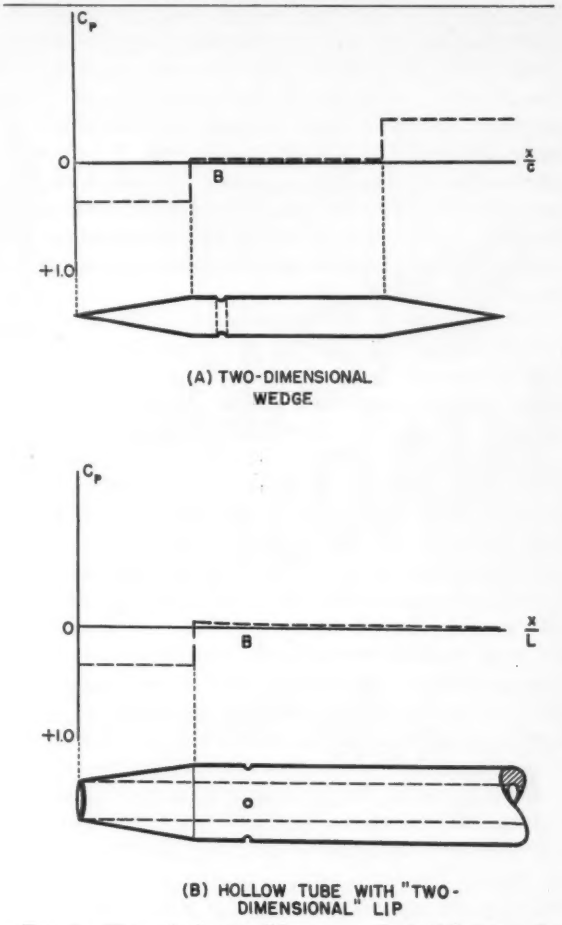


FIG. 3. Theoretically possible means of obtaining true free-stream static pressure at supersonic speeds.

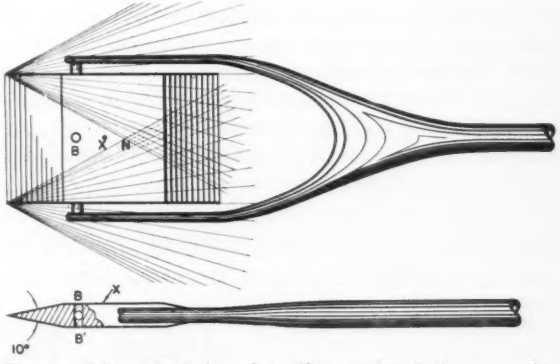


FIG. 4. Schematic design of a self-correcting device measuring free-stream pressure at supersonic speeds.

## PROPOSED DEVICE

Fig. 4 exhibits a possible design of a free-stream static-pressure-measuring device that would give accurate values independently of angle of attack, angle of

* This can be seen by expanding the reasoning in the second footnote of this paper. The percentage increase in radius of the stream-tube ring as it rounds the shoulder is insignificant. Therefore, the stream lines in the immediate vicinity of the corner have essentially the same shape and the same velocity variation as in the case of a two-dimensional shoulder.

yaw, and Mach Number (above a certain threshold Mach Number, say 1.4). It consists of a double-wedge airfoil with a flat area on which the static-pressure orifices $B$ and $B'$ are located. A pivot arrangement (with adequate internal friction to damp out transients) is shown upstream of the aerodynamic center, $X$, but actually need not be included, especially for work in supersonic tunnels (where direction of the stream is accurately known). Even without the pivot, manifolding of orifices $B$ and $B'$ together provides adequate correction for angle of attack.

Let us return to the requirements for the device as enumerated previously. Requirements (a) and (d) adequately met, since the theoretical pressure ratio varies between 1.001 and 1.003 for Mach Numbers between 1.5 and 3.5. (It will be remembered that at supersonic speeds the flow is two-dimensional within the triangle $NN_1N_2$ of Fig. 4a, since the effect of the finiteness of the airfoil is propagated within Mach cones centered at $N_1$ and $N_2$.) Requirement (b) is satisfied better than on other designs, since the orifices are located in a region where the boundary-layer effect is not critical. There is also the possibility of making the flat faces inclined toward each other by a small angle corresponding to the average slope of the boundary-layer displacement thickness near the orifices. However, the effect is so small that the ensuing production difficulties do not warrant the step. Requirement (c) is provided for by the pivot arrangement maintaining essentially a zero angle of attack and/or by the common manifolding of the pressure orifices $B$ and $B'$. One of the rather "pretty" aspects of the present design resides in the manner in which it is self-correcting for yaw. By the sweepback principle it is clear that those changes in pressure across the leading-edge shockwave and the expansion wave around the shoulder which are caused by yaw are compensating. Here again, the advantage of matching two-dimensional compression with two-dimensional expansion is apparent. The hardest of the requirements to meet, requirement (e), is satisfied to the same degree as requirement (b), because the angle of attack is kept zero automatically and the Mach Number effect is essentially nonexistent. Thus, little coupling between the various errors exists in the present case. By way of contrast, it is recalled that the flow of boundary-layer air from "lower surface to upper surface" in the vicinity of the orifices, which decreased the accuracy of the cone-cylinder probe, is suppressed completely by the two-dimensional arrangement. Requirement (f) of low response lag may be satisfied by standard procedure of pressure-system balancing. However, care must be taken that the pivot arrangement should not introduce unsteady effects of its own. Requirement (g) of minimizing conversion errors may be satisfied to the same extent as on any other comparable device. On the other hand, the present device compares unfavorably with pitot-static-type device with respect to requirement (h), in that its drag is several times higher. Where accuracy is needed, the drag consideration is likely to be secondary. Thus, it would appear that the device of Fig. 4 either excels or matches the performance of similar instruments with respect to all cited criteria except for the higher drag characteristic.

It is, of course, clear that the static measurement obtained with the present device can be used in conjunction with other measurements to obtain other information, notably the Mach Number. For this use, the device should be coupled with a calibrated total pressure tube (such as a rather small open-nose rigid tube insensitive to angle of attack up to approximately 10°). Since the static-pressure reading does not depend upon Mach Number, the calibration of the resulting "Mach Number meter" is a relatively simple matter.

## Conclusion

In conclusion, it is perhaps proper to reflect upon the reason why this obvious scheme has not been advanced before—our "subsonic blindness." At subsonic speeds there is no such thing as a two-dimensional airfoil behavior outside of a two-dimensional tunnel. The effect of the finite span is felt everywhere, and, if one were to use a "two-dimensional" static-pressure-measuring device, sizable and mostly unpredictable corrections would be called for. Such considerations make the pitot-static type of a probe a natural solution. It is this subsonic thinking habit—intuition if you wish—that made us miss the present solution heretofore.

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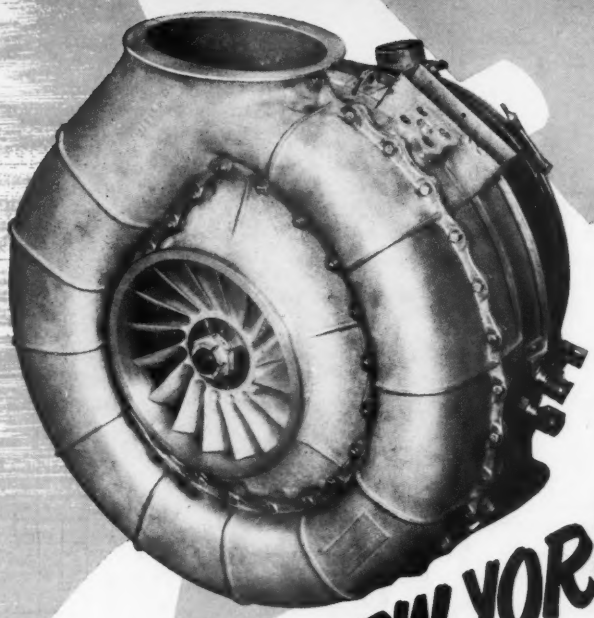

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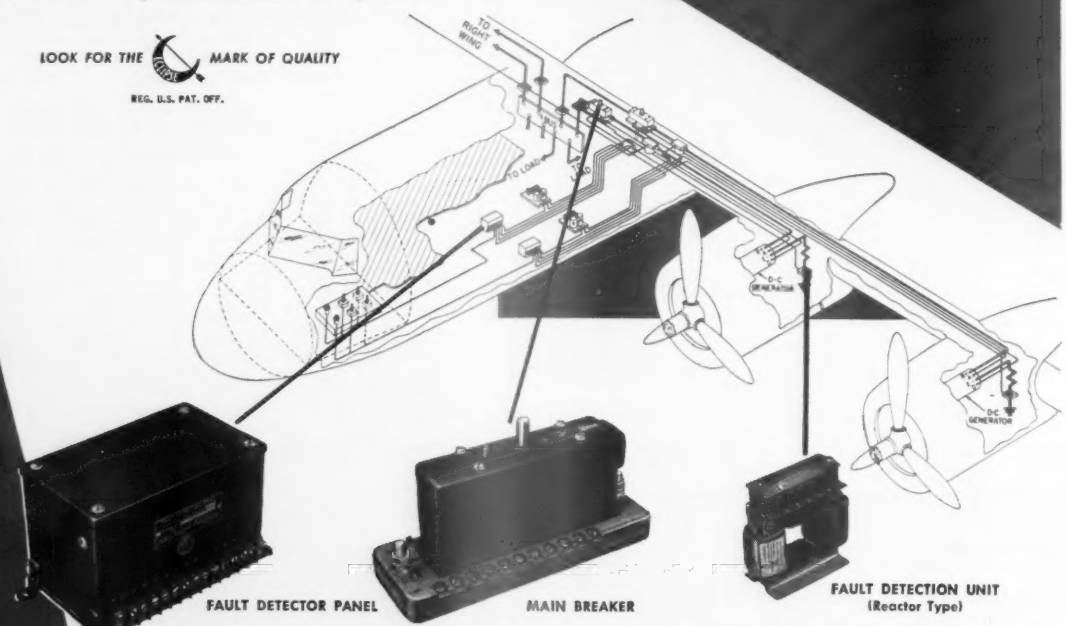


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# Aerodynamics (2)

## AERODYNAMIC LOADS

**The Estimation of Critical Mach Number. II.** G. H. Lee. *The Aeroplane*, Vol. 59, No. 2046, August 25, 1950, pp. 216–221, illus. 9 references. Several methods for estimating critical Mach Number and application of these methods for sweptback wings, wing-body combinations, and tail surfaces.

**An Analysis of the Normal Accelerations and Airspeeds of a Four-Engine Airplane Type in Postwar Commercial Transport Operations on Trans-Pacific and Caribbean-South American Routes.** Thomas L. Coleman and Paul W. J. Schumacher. *U.S., N.A.C.A., Technical Note No. 2176*, August, 1950. 18 pp., illus. 8 references.

## BOUNDARY LAYER

**Note on Sintered Metal with a View to Its Use As a Porous Surface in Distributed Suction Experiments.** H. H. Preston and A. G. Rawcliffe. *Gt. Brit., Aeronautical Research Council, Current Papers No. 9*, 1950 (February 9, 1946). 11 pp., illus. 4 references.

The properties of sintered bronze (Porosint) and results of tests on representative samples of several grades of it available for commercial use. The porosity of beechwood and plaster of Paris was also measured. Porous bronze appears to be the best porous material so far discovered for use in model construction. It can be welded or soldered to solid parts, but the surface cannot be machined. The finer grades should meet the requirements for distributed suction tests. Pores are fine and closely spaced. The resistance of the finer grades is of the viscous type—i.e., pressure drop varies directly as velocity and inversely as thickness.

**Tests on a "Lighthill" Nose-Suction Aerofoil in the N.P.L. 4 Ft. No. 2 Wind Tunnel.** F. Cheers, W. G. Raymer, and Ola Douglas. *Gt. Brit., Aeronautical Research Council, Performance Sub-Committee, Report No. 10,506*, April 15, 1947. 13 pp., illus. 3 references. (To be published as *Reports and Memoranda No. 2355.*)

Tests on an 8.6 per cent thick nose-suction airfoil were made at Reynolds Numbers of 0.385 and $0.577 \times 10^6$. The wing stalled at $\alpha = 13°$ ($C_{NF} = 1.08$) without suction, the coefficient at the stall increasing approximately linearly with suction quantity and reaching 1.72 at $C_Q = 0.019$ and 23° incidence.

**Remarks on the Interaction Between Shock Waves and Boundary Layer in Transonic and Supersonic Flow.** Lester Lees. (*U.S., Navy, Project Squid, Technical Memorandum No. Pr-1.*) *Princeton University, Aeronautical Engineering Department, Report No. 20*, November 1, 1947. 23 pp., illus. 4 references.

The interaction between a shock wave and a laminar boundary layer depends critically on the boundary-layer thickness. Examination of the flow within the laminar boundary layer shows that the reflection conditions are satisfied by a Prandtl-Meyer expansion. For the turbulent boundary layer, reflection conditions require a reflected shock wave. The influence of Reynolds Number and Mach Number of the interaction was investigated. In the consideration of flow around a sharp corner: If the boundary layer ahead of the shock is laminar, the shock front is curved, total pressure rise is diffused in both directions away from the sharp corner, and the interaction extends for a considerable distance upstream; if the boundary layer is turbulent ahead of the shock, the curvature of the boundary layer is sharp, the pressure rise occurs at the corner, and the region of interaction is concentrated at the corner. The fundamental differences between boundary layer interacting with a supersonic external flow and the Prandtl subsonic boundary layer were investigated with the use of the equations of mot'on.

**Some Experiments on the Interaction of Shock Waves with Boundary Layers on a Flat Plate.** F. W. Barry, A. H. Shapiro, and E. P. Neumann. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 126–131, illus. 10 references.

## CONTROL SURFACES

**Nose Controls on Delta Wings at Supersonic Speeds.** B. W. Bolton Shaw. *College of Aeronautics, Cranfield, England, Report No. 36*, May, 1950. 65 pp., illus. 4 references.

The nose controls considered are equal, flat, triangular surfaces located symmetrically on each side of a flat delta wing or tail plane, with the hinge lines meeting at the apex; the controls may act either as ailerons or elevators. Lift forces and rolling moments are calculated using the assumptions of the linearized theory, determining the rate of change of $C_L$ of delta tail plane with elevator angle and nondimensional derivative of rolling moment with aileron angle. Flow over the wing and tail plane when the leading edges lie inside the Mach cone and when the leading edges lie outside the Mach cone is considered. At supersonic speeds, nose controls are suitable for delta wings and tail planes of moderate aspect ratio (>4), but are ineffective for low aspect ratio plan forms (<1). The effectiveness is comparable to, but less than, that of trailing-edge controls. Results of calculations are presented in plots.

**Note on the Dependence of Flap Hinge Moment Derivatives on Hinge Position.** W. J. Duncan. *Aeronautical Quarterly*, Vol. 2, Part 2, August, 1950, pp. 143–145. 2 references.

Information on hinge-moment derivatives based only on kinematics and statics. The derivative of hinge moment of a plain flap with the angular setting of the flap varies parabolically with the chordwise position of the hinge; the derivative of the hinge moment with incidence of the main surface varies linearly with the hinge position. Results apply to flaps in both two and three dimensions.

**Theoretical Characteristics in Supersonic Flow of Two Types of Control Surfaces on Triangular Wings.** Warren A. Tucker and Robert L. Nelson. *U.S., N.A.C.A., Report No. 939*, 1949. 16 pp., illus. 10 references. U.S. Govt. Printing Office, Washington. $0.20.

**Note on a "Scissors-Type" of Dynamic Balance for Control Surfaces.** R. A. Frazer. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2369*, 1950 (July 14, 1941). 7 pp., illus. 1 reference. British Information Services, New York. $0.40.

**Summary of Section Data on Trailing-Edge High-Lift Devices.** Jones F. Cahill. *U.S., N.A.C.A., Report No. 938*, 1949. 30 pp., illus. 58 references. U.S. Govt. Printing Office, Washington. $0.25.

## FLUID MECHANICS & AERODYNAMIC THEORY

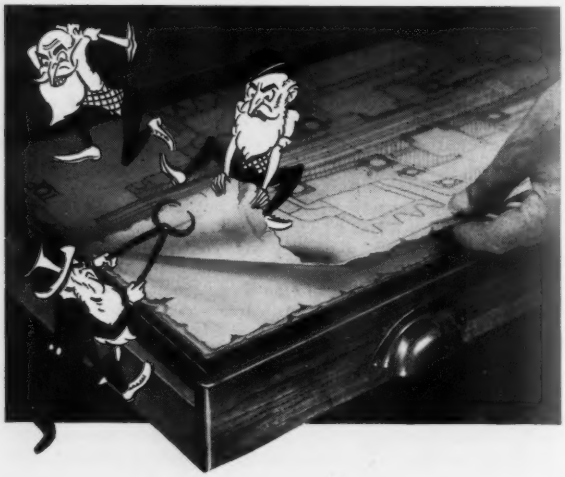
**The Eddy Viscosity in Turbulent Shear Flow.** A. A. Townsend. *Philosophical Magazine*, Vol. 41, No. 320, September, 1950, pp. 890–906, illus. 4 references.

Wake development is largely due to the formation of a group of large eddies whose function is mainly convective. Attempts to derive local values of turbulent intensity and eddy viscosity require a consideration of the entire wake flow. A control sequence is outlined in which the intensity of the large eddies controls the level of eddy viscosity. Energy balance of the large eddies was derived, and their properties and structures were studied by measuring the spectrum functions of the velocity fluctuation components in the wake of a circular cylinder. Large eddies are long cylindrical structures, elongated in the main stream direction. They are randomly placed in the main stream direction, cover more than half of the wake, and have their vorticity generally in the direction of maximum positive mean rate of strain. The generation of Reynolds shear stresses by distortion of quasistationary turbulent fields is discussed, and applications of the eddy viscosity hypothesis are suggested.

**Plane Rotational Prandtl-Meyer Flows.** M. H. Martin. *Journal of Mathematics and Physics*, Vol. 29, No. 2, July, 1950, pp. 76–89. 8 references.

Mathematical consideration of a steady, plane flow of a gas subjected to no external forces, assuming that the effects due to heat and friction are negligible. Basic confluent flows are defined, although this process is applied here to only the general Prandtl-Meyer flow of physical gases. The Bernoulli function and the direction function of the flows are found, and general flows are classified into four types. The analysis is extended to cover two of these types: isoenergetic, anisentropic flow and nonisoenergetic, isentropic flow. The network hodograph curves (known as characteristics) are derived for these flows. The characteristics in the hodograph plane for rotational flows do not have to be the same for all flows in the physical plane which have the same Bernoulli function. With a given Bernoulli function, it is possible to have a two-parameter family of hodograph curves instead of two one-parameter families.

**Transonic Potential Flow of a Compressible Fluid.** W. R. Sears. *Journal of Applied Physics*, Vol. 21, No. 8, August, 1950, pp. 771–778, illus. 20 references.



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Even with the assumptions of irrotational isentropic flows, the equations of gas flow are relatively unmanageable for mixed transonic situations. Approximate methods of solution are discussed briefly, as well as the hodograph method, which gives exact solutions of the equations for plane flow. Although all the methods predict smooth, potential mixed flows that have regions of supersonic speed and acceleration and deceleration at the speed of sound, there is no experimental proof of the existence of such flows. Explanations for the discrepancy between experiment and theory are reviewed; none has led to a complete solution to date. Kuo's stability calculations are described briefly; his results show that stable, smooth, mixed flows may exist under certain conditions.

**On the Asymptotic Expansion in Three-Dimensional Compressible Viscous Flow.** M. Z. Krzywoblocki. *Franklin Institute, Journal*, Vol. 250, No. 3, September, 1950, pp. 213–217. 5 references.

Application of an asymptotic expansion for two-dimensional steady flow of a compressible viscous fluid to flow along a yawed flat plate whose plane is parallel to the direction of undisturbed flow. An approximate solution for the basic flow equations is presented. An exact solution for the boundary conditions around the plate is derived, neglecting the velocity potential function.

**The Sound Waves Generated by a Particle at Supersonic Speed.** M. H. Martin and G. B. Jackson. (*Schweizer Archiv*, Vol. 16, No. 4, April, 1950, pp. 114–119.) *Engineers' Digest*, Vol. 11, No. 9, September, 1950, pp. 313, 314, illus. 2 references.

Investigation of sound waves generated by a particle in curvilinear motion, motion affected by gravity and air resistance, and of sound waves in space. Sound waves generated by a particle moving on a curvilinear path are convex or concave to an observer in front of the waves and on the positive side of the trajectory. The sound-wave front of a trajectory under gravity and air resistance is convex to an observer in front of the wave and passes each position of the plane no more than once. In the three-dimensional case, the sound waves along the trajectory are spheres rather than circles. The wave fronts are concave and will develop singularities.

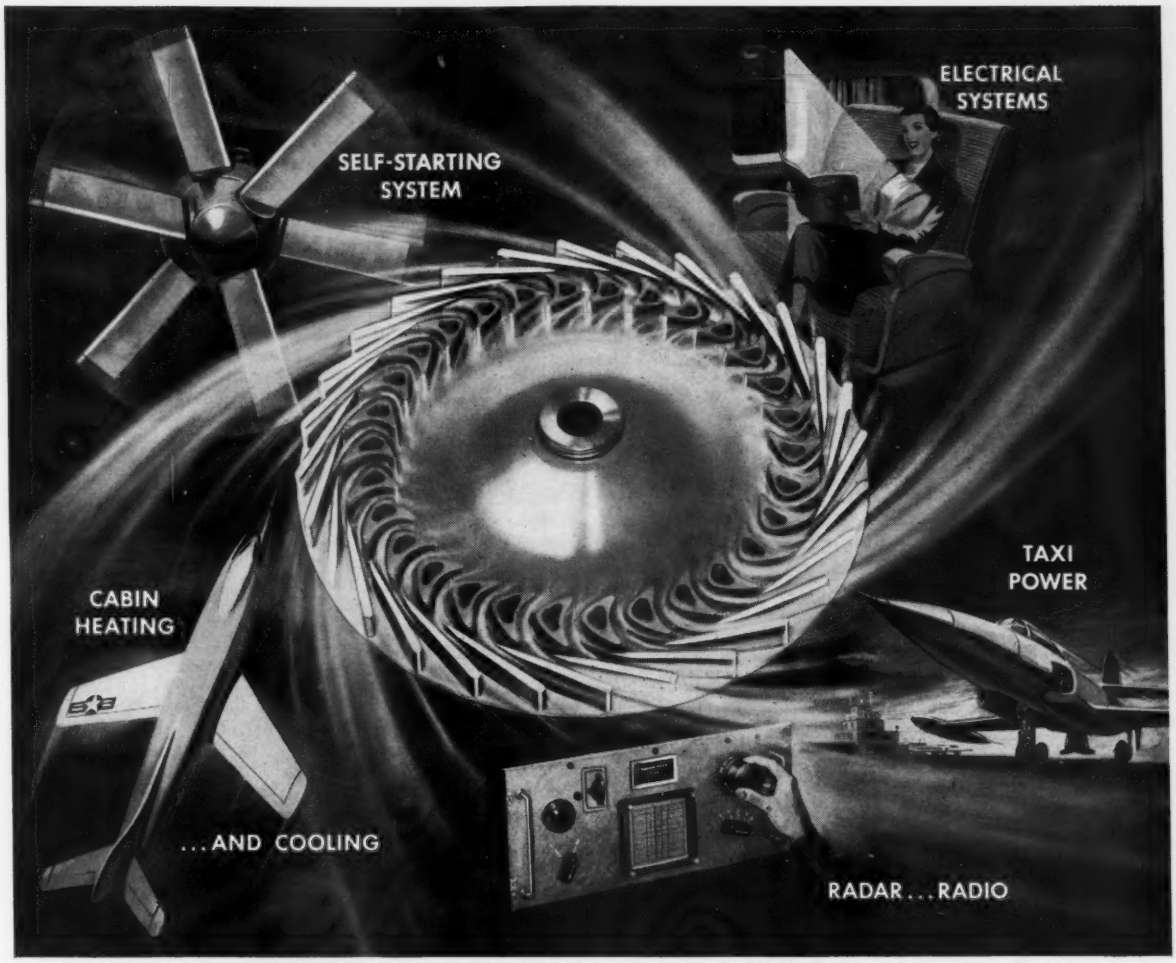
**The Propagation of a Sound Pulse in the Presence of a Semi-Infinite, Open-Ended Channel. II.** W. Chester. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 203, No. 1072, September 7, 1950, pp. 33–42, illus. 4 references.

The author, in two previous papers, considered the disturbance produced inside a two-dimensional open-ended channel when a sound wave approaches the open end. At large distances from the open end, the disturbance was assumed to be a plane wave traveling into the channel, and expressions were derived for the potential and velocity distributions of the plane wave. This paper discusses the asymptotic behavior of the disturbance at large distances from the wave front. By making use of analogous problems for a harmonic wave, the results are treated as Fourier transformations. The asymptotic behavior for an arbitrary initial pulse is outlined, and several typical examples of this condition are given. The results of these equations are used to estimate the energy returns along the channel when the initial pulse is of finite duration.

**Spectral Tensor of Homogeneous Turbulence.** (Symposium on Turbulence, July 1, 1949.) J. Kampé de Fériet. *U.S., Naval Ordnance Laboratory, Report No. 1136*, July 1, 1950. pp. 1–31, illus. 27 references.

Discussion of four correlation tensors in a homogeneous turbulence as a step towards an understanding of the entire theory of turbulent diffusion. The turbulent velocity fluctuations are represented by a random vector field. From this random field, statistical, space, time, and space-time averages are computed to describe the statistical properties of the turbulent velocity fluctuations. Consideration of the statistical correlation tensor and the statistical spectrum tensor shows that the components of the spectral tensor are not pure step functions; that the energy spectrum is not a pure rays spectrum; and that, if some rays are present, they are of little importance. The assumption that the space-average correlation tensor is identical for almost all sample functions with the statistical correlation tensor is incompatible with the more recent assumption that a sample function belongs to the class of Fourier-Stieltjes transforms of functions of bounded variation.

**The Small-Scale Structure of Turbulent Motion.** G. K. Batchelor. (Symposium on Turbulence, July 1, 1949.) *U.S.*,

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*Naval Ordnance Laboratory, Report No. 1136,* July 1, 1950, pp. 33–41, illus. 6 references.

Measurements were made of the so-called flattening factor of the probability distributions of the first few space derivatives of the velocity fluctuations, based on the theory of local similarity of Kolmogoroff. The velocity fluctuations are normally distributed, but the probability distributions of the velocity derivatives are far from normal. The energy associated with the small-scale components of the motion is unevenly distributed in space and is roughly confined to regions that become smaller as eddy size decreases. The spatial nonuniformity of the activation of the small-scale components is intrinsic to the equilibrium range of the wave numbers and is not produced or effected by the large-scale components of the motion. The total amount of energy associated with a small-scale component seems to be only slightly affected by the spatial nonuniformity. The energy of the small-scale motion manifests itself as a "whirl"—i.e., a region of high energy in the midst of a region of low energy.

**On Heisenberg's Elementary Theory of Turbulence.** S. Chandrasekhar. (Symposium on Turbulence, July 1, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1136,* July 1, 1950, pp. 43–48. 2 references. Explicit solutions to the questions of the spectrum of stationary turbulence and the spectrum of turbulence during decay.

**Investigation of the Turbulence Characteristics of an Experimental Low-Turbulence Wind Tunnel.** H. Schuh and K. G. Winter. (Symposium on Turbulence, July 1, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1136,* July 1, 1950, pp. 49–66, illus. 4 references.

Measurements of the longitudinal intensity of turbulence in the R.A.E. 4- by 3-ft. wind tunnel by hot-wire tests. For these tests, a transformer was inserted in the circuit between the hot-wire bridge and the amplifier, and the wire was held in rigid mount. Intensity measurements are plotted for fluctuating velocity as a percentage of local velocity vs. local velocity. The turbulence spectrum is presented in curves of the product of frequency and spectrum function vs. the frequency. Noise makes a large contribution to the turbulence in the tunnel. The elimination of nonuniformities in the flow approaching the fan is important in the consideration of fan noise. The damping effect of the screens was investigated, and the damping effect on the local velocity is greater than that given by Dryden.

**On Turbulent Diffusion.** F. N. Frenkiel. (Symposium on Turbulence, July 1, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1136,* July 1, 1950, pp. 67–86, illus. 6 references.

Investigation of turbulent diffusion in a fluid at rest and in fluid flow with the application of statistical theories of turbulence. In a fluid at rest, the variance of the turbulence is proportional to the time interval $t$ for large values of $t$. When $t$ is small compared with the Lagrangian scale of turbulence, the variance is proportional to the square of the time of diffusion. The standard deviation of the spread is proportional to the time of diffusion at the beginning of the diffusive process and is proportional to the square root of this time near the end of the diffusive process. In fluid flow, the results of this method correspond to the one-dimensional case investigated by G. I. Taylor. Experimental measurements of turbulent diffusion from a point source are presented as an illustration.

**Asymptotic Expansions for the Hypergeometric Functions Occurring in Gas-Flow Theory.** T. M. Cherry. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences,* Vol. 202, No. 1071, August 22, 1950, pp. 507–522, illus. 9 references.

Asymptotic formulas of two sorts are found for the hypergeometric functions, of large order $\nu$, which arise when gas flows are investigated by the hodograph method. These functions are monotomic for "subsonic" values of the argument $\tau$, oscillating for "supersonic" values. Elementary formulas, involving exponential or circular functions and singular at the sonic value $\tau = \tau_s$, are developed to the terms in $\nu^{-4}$. When $\tau$ is near $\tau_s$, these formulas give poor approximation. Formulas giving uniform approximation near $\tau_s$, involving Bessel functions, are developed to the terms in $\nu^{-4}$. These give seven-figure accuracy over the physically significant range of $\tau$, for $|\nu| \geqslant 10$. The coefficients are tabulated for $\tau = 0(0.02)\,0.50$ for the case where the adiabatic index $\gamma$ of the gas is 1.4.

**Prandtl-Meyer Flow Behind a Curved Shock Wave.** Robert C. Rand. *Journal of Mathematics and Physics,* Vol. 29, No. 2, July, 1950, pp. 124–132, illus. 2 references.

Construction of a free stream compatible with Prandtl-Meyer flow and a curved shock wave; comparison of the free stream with a uniform stream. The flow downstream of the shock wave is first determined, and the shock wave and free stream consistent with the flow is constructed. An equation is derived for the curved shock separating the regions of Prandtl-Meyer flow and the region of uniform flow, and the properties of this shock are examined. A quantitative analysis of the velocity and stagnation pressure of the constructed stream is then made. For sharp profiles, the Prandtl-Meyer flow behind the shock is in good agreement with the flow produced by an isentropic free stream if the viscosity effects of the Prandtl-Meyer flow are neglected. But for blunt profiles and at high Mach Numbers, the Prandtl-Meyer flow is not a good approximation of the flow produced by a uniform stream.

**Remarks on the Interaction Between Shock Waves and Boundary Layer in Transonic and Supersonic Flow.** Lester Lees. (*U.S., Navy, Project Squid, Technical Memorandum No. Pr-1.*) *Princeton University, Aeronautical Engineering Department, Report No. 20,* November 1, 1947. 23 pp., illus. 4 references.

The interaction between a shock wave and a laminar boundary layer depends critically on the boundary-layer thickness. Examination of the flow within the laminar boundary layer shows that the reflection conditions are satisfied by a Prandtl-Meyer expansion. For the turbulent boundary layer, reflection conditions require a reflected shock wave. The influence of Reynolds Number and Mach Number of the interaction was investigated. In the consideration of flow around a sharp corner: If the boundary layer ahead of the shock is laminar, the shock front is curved, total pressure rise is diffused in both directions away from the sharp corner, and the interaction extends for a considerable distance upstream; if the boundary layer is turbulent ahead of the shock, the curvature of the boundary layer is sharp, the pressure rise occurs at the corner, and the region of interaction is concentrated at the corner. The fundamental differences between boundary layer interacting with a supersonic external flow and the Prandtl subsonic boundary layer were investigated with the use of the equations of motion.

**Some Experiments on the Interaction of Shock Waves with Boundary Layers on a Flat Plate.** F. W. Barry, A. H. Shapiro, and E. P. Neumann. *Journal of Applied Mechanics,* Vol. 17, No. 2, June, 1950, pp. 126–131, illus. 10 references.

**Readers' Forum: A Note on the Calculation of Oblique Shock Wave Characteristics.** M. J. Thompson. *Journal of the Aeronautical Sciences,* Vol. 17, No. 11, November, 1950, p. 744. 4 references.

**Lift on Inclined Bodies of Revolution in Hypersonic Flow.** G. Grimminger, E. P. Williams, and G. B. W. Young. *Journal of the Aeronautical Sciences,* Vol. 17, No. 11, November, 1950, pp. 675–690, illus. 21 references.

**Density Fields Around a Sphere at Mach Numbers 1.30 and 1.62.** Paul B. Gooderum and George P. Wood. *U.S., N.A.C.A., Technical Note No. 2173,* August, 1950. 52 pp., illus. 6 references.

**An Approximate Solution for Incompressible Flow About an Ellipsoid near a Plane Wall.** Phillip Eisenberg. *Journal of Applied Mechanics,* Vol. 17, No. 2, June, 1950, pp. 154–158, illus. 5 references.

**The Flow over a Wedge Profile at Mach Number 1.** G. Guderley and H. Yoshihara. *Journal of the Aeronautical Sciences,* Vol. 17, No. 11, November, 1950, pp. 723–735, illus. 4 references.

**Aerodynamics of Supersonic Aircraft and Missiles.** W. Bollay. (Symposium on Ordnance Aeroballistics, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1131,* March 1, 1950, pp. 27–49, illus.

Supersonic aerodynamics as applied to missiles and aircraft is rather similar to subsonic aerodynamics in its techniques, both theoretical and experimental. The supersonic wind tunnel is the most reliable experimental instrument for the quantitative determination of aerodynamic characteristics, but the tunnel must have good flow characteristics and excellent instrumentation. The construction and operation of the North American Aviation, Inc. 16-in. supersonic wind tunnel is described. For aerodynamic tests, small tunnels with good velocity distributions are likely to be better than large tunnels operating at low-pressure levels. For proof-testing of propulsion systems whose model laws are not known, large propulsion test facilities operating at low pressures may be required.

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**Problems of Missiles at Extreme Speeds.** R. Smelt. (Symposium on Ordnance Aeroballistics, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1131*, March 1, 1950, pp. 51–68, illus. 6 references.

Properties of a missile traveling at high supersonic speed may be different from those expected on the basis of perfect-gas aerodynamics. There is difficulty in experimental work since the wind tunnel provides essentially perfect-gas data. Up to Mach 7 such data are probably adequate since the major effect of changes inside the gas molecule itself is not important until temperatures corresponding to stagnation conditions at this Mach Number are reached. Above Mach 7 it appears necessary to supplement hypersonic wind-tunnel work with experimental work at the correct temperature. Experiments on projectiles in free flights seem to be a practical solution.

**Aerodynamics Research for Guided Missiles.** H. M. Mott-Smith. (Symposium on Ordnance Aeroballistics, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1131*, March 1, 1950, pp. 19–25.

At present the most promising field of aerodynamic investigation for short-range missiles appears to be the development of a series of configurations that would have appropriate stability and control over an extended speed range. Basic and applied research in transonic as well as supersonic speed ranges is needed more than the study of particular missiles and air-frame models.

**Free-Flight Roll of a Simple Arrow Projectile.** A. C. Charters. (Symposium on Ordnance Aeroballistics, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1131*, March 1, 1950, pp. 1–17, illus.

A description of the aerodynamics range of the Ballistics Research Laboratories and the theory of roll motion of arrow projectiles. Results obtained from the firing of arrow projectiles were in sufficient agreement with theory to indicate that the range is a suitable instrument for measuring the aerodynamic properties of the rolling motion of simple arrow projectiles.

## INTERNAL FLOW

**On the Transonic Flow of a Compressible Fluid Through an Axially Symmetrical Nozzle.** S. Tomotika and Z. Hasimoto. *Journal of Mathematics and Physics*, Vol. 29, No. 2, July, 1950, pp. 105–117, illus. 6 references.

Investigation of the steady, irrotational flow of a real gas, subject to adiabatic law, through an axially symmetric nozzle with circular cross-section. A new hypothetical gas is introduced which can approximate the real gas in the region where the fluid velocity becomes equal to the local velocity of sound. The flow of this hypothetical gas is governed by a nonlinear equation of motion of the mixed type, which is basically a simplified version of the fundamental equation of motion derived by von Kármán in his work on the similarity law of transonic flow. This equation is solved for an exact solution that explains the possible transition from a symmetric type of flow to an asymmetric type for the case of transonic flow in the axially symmetric nozzle. After detailed numerical calculations have been carried out, the results are compared with Stanton's experimental work. It is concluded that there is a limit to the symmetric type of flow. The manner in which the limiting form of the symmetric type of flow can be continued to the asymmetric flow is explained by this process.

**A Method of Estimating Optimum Turbine Operating Conditions for a Range of Nozzle and Blade Angles.** E. Duncombe. *Canada, National Research Council, Report No. MT-13*, June 2, 1950. 56 pp., illus. 7 references.

Preparation of performance grids for nozzles and blades based on previous turbine cascade studies; application of these grids to a stage-by-stage method of calculating turbine characteristics for compressible flow. The method is applied to some design point relationships between gas angles, efficiency, and work. Efficiency curves are plotted on a basis of gas outlet angle. The criterion for maximum mass flow was often blade choking rather than nozzle choking, in cases where blade and nozzle angles were approximately equal, or at high speeds. The relationship is given for work obtainable from the turbine. Turbine efficiencies calculated on the basis of incompressible flow are slightly less than those for compressible flow. The development of the equations governing calculation of turbine characteristics and a sample calculation of a turbine operating point are included.

**The Sonic Barrier in Centrifugal and Axial-Flow Compressors.** C. Pfleiderer. *Engineers' Digest*, Vol. 11, No. 9, September, 1950, pp. 316–318, illus. 5 references.

Development of a simple method for obtaining optimum conditions in axial-flow and centrifugal compressors with and without inlet guide vanes. Optimum conditions keep the maximum velocity near sonic speed, without exceeding it. An analogy is made between compression shock phenomena due to supersonic speeds in centrifugal compressors and cavitation phenomena in centrifugal pumps.

**Turning-Angle Design Rules for Constant-Thickness Circular-Arc Inlet Guide Vanes in Axial Annular Flow.** Seymour Lieblein. *U.S., N.A.C.A., Technical Note No. 2179*, September, 1950. 23 pp., illus. 8 references.

**Axially-Symmetrical Supersonic Flow Near the Centre of an Expansion.** N. J. Johannesen. *Aeronautical Quarterly*, Vol. 2, Part 2, August, 1950, pp. 127–142, illus. 7 references.

Approximate solution for the isentropic, irrotational, steady two-dimensional or axially-symmetric flow of a perfect gas near the center of an expansion that is not a simple wave. The solution is designed to replace the method of characteristics in such a region. The equations of motion are derived, and the boundary conditions are set up. The method is applied to a jet issuing from a nozzle, and a formula is derived for the initial curvatures of the boundary of the jet at the nozzle lip. The solution applies also to the flow near an edge in the surface of a body of revolution, or in the wall of a duct of circular cross section; the velocity gradient on the wall just downstream of the edge may be determined. The point where the shock wave starts is estimated. By using the shock-wave equations instead of the solution for the centered expansion, the method can be adapted to an approximate treatment of the flow near the lip or edge with an attached shock wave.

## PARASITIC COMPONENTS & INTERFERENCE

**The Calculation of the Scoop Drag for a General Configuration in a Supersonic Stream.** Harold Klein. *Douglas Aircraft Company, Inc., Report No. SM-13744*, April 12, 1950. 43 pp., illus. 7 references.

The concept of additive drag used in ram-jet analysis is inconsistent with the definition of the pressure drag on the complete fuselage or body. A "scoop incremental drag" is defined as a correction to the pressure drag computed for the fuselage; it replaces the additive drag and must be added to the usual thrust and drag of the airplane to obtain the net force. Equations are derived which allow computation of the scoop incremental drag; charts present this drag directly for a typical class of airplane geometries. The method has no restrictions as to symmetry or shock pattern preceding the inlet. Checks against other analytic approaches were made for the cases of a nose inlet and for a two-dimensional wholly supersonic oblique shock inlet. These checks showed that drag computations with the scoop incremental drag gave results comparable with other analytical methods.

**The Drag Effects of Roughness at High Sub-Critical Speeds.** A. D. Young. (Paper Read at International Congress of Applied Mechanics, Paris, 1946.) *Royal Aeronautical Society, Journal*, Vol. 54, No. 476, August, 1950, pp. 534–540, illus. 7 references.

Measurements of the profile drag of a metal-covered N.A.C.A. 0012 airfoil with five grades of camouflage paint were made in the R.A.E. High Speed Tunnel. Roughness records were taken with the Tomlinson roughness gage. Compressibility had no appreciable effect on the drag increase due to roughness. Correlating the drag effect of each finish with an equivalent size of sand roughness $K_e$ called for finding the equivalent sand roughness height of each paint and its variation with Reynolds Number. Charts based on the Prandtl and Schlichting results for the drag of sand-roughened plates with fully turbulent boundary layers were used to predict the effect of the various finishes on the drag of wings and bodies for a range of wing chords, body lengths, forward speeds, and heights. The variation in true speed is presented graphically. If the surface finish is equivalent to that of standard camouflage paint carefully applied, no serious effects on speed and performance are expected. Permissible tolerance of the finish becomes smaller as altitude decreases.

## PERFORMANCE

**General Performance Reduction Equations for Reciprocating-Engined Aircraft with Constant-Speed Propellers.** W. J. D.

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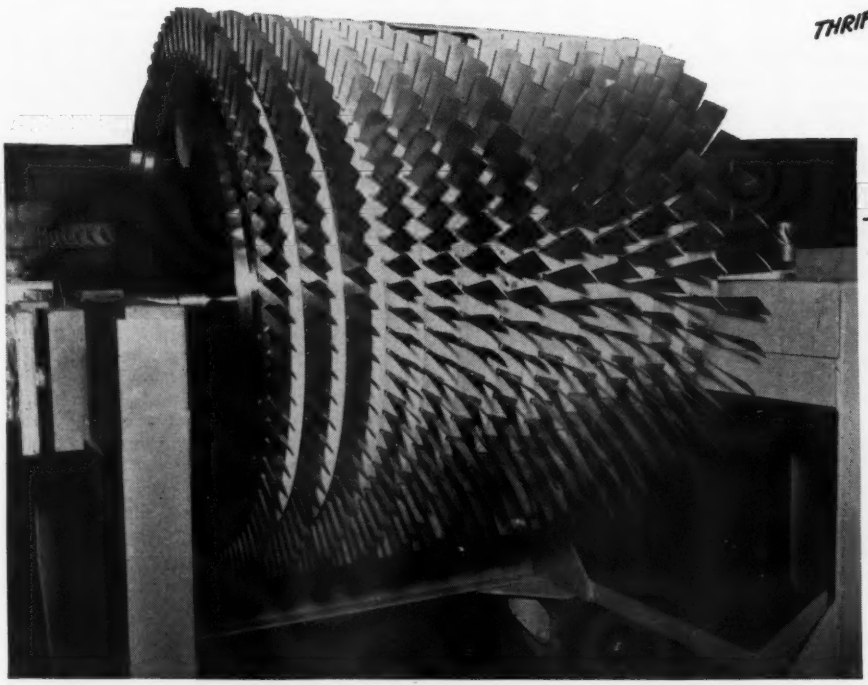

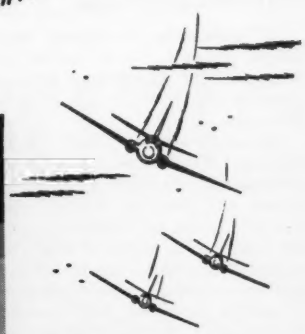

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Annand. *Aeronautical Quarterly*, Vol. 2, Part 2, August, 1950, pp. 111–126, illus. 4 references.

Extension of Cameron's method to the development of more general equations for the correction of level speed and rate of climb for variations of air temperature and aircraft weight, at constant air pressure and propeller r.p.m., allowing for the effects of compressibility on aircraft drag and propeller efficiency and for the effect of ram on engine power. The relations may be applied to aircraft powered by any type of reciprocating engine driving a constant-speed propeller. From these equations it is possible to construct sets of curves for engine performance where compressibility effects on drag and propeller efficiency are appreciable. The method is illustrated in a worked example.

## STABILITY & CONTROL

**An Introduction to Aircraft Stability Theory Using Current British Notation.** J. R. Baxter and J. M. Evans. *Australia, Department of Supply and Development, Aeronautical Research Laboratories, Report No. A. 68*, March, 1950. 68 pp., illus. 16 references.

An outline of the derivation of the basic equations of motion, followed by the setting up of the stability equations and a brief discussion of the types of motion possible. The basic theory is defined in a proposed standard nondimensional notation system that is based on the notations in use in Great Britain and adopts the semispan as the unit of length in all cases. Relationships between the derivatives are defined in terms of the lift, drag, thrust, side-force, and moment coefficients. This notation system is applied to an outline of the solution of the equations for small disturbances. Tables of the general and nondimensional motion systems are included.

**The Response of an Aeroplane to Application of the Elevators.** L. W. Bryant and R. W. G. Gandy. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2275*, 1950 (May, 1941). 46 pp., illus. 8 references. British Information Services, New York. $1.80.

The response in pitching velocity and incidence was calculated for a typical airplane, using nondimensional notations and covering a variety of c.g. positions and a range of tail volumes. Calculations are carried out for a comparison of stick forces on the basis of a given elevator movement and a given change of pitch, and the numerical values are presented in tables. Equations are evolved for the stick forces needed to hold a speed different from the trimming speed. Stick forces cannot be made lighter for the same c.g. range by increasing tail volume and making the rate of change of the hinge-moment coefficient with tail incidence more negative unless elevator movements are comparatively slow. An extension of the method is applied to the determination of stick forces needed in pulling out of a dive without changing the tab setting from that which trims in the dive. The limiting factor here is the maximum acceleration produced normal to the wings. A series of calculations is carried out for a typical fighter and a bomber.

**The Forces Produced by Fuel Oscillation in a Rectangular Tank.** E. W. Graham. *Douglas Aircraft Company, Inc., Report No. SM-13748*, April 13, 1950. 14 pp., illus. 1 reference.

Mathematical study of the effect on airplane dynamic stability of small sinusoidal fuel oscillations in a stationary rectangular tank. The fuel is replaced by a simple pendulum with a fixed mass, and the equivalent simple pendulum is determined. The pressure distribution in the tank and the frequency of the wave motion are obtained from Lamb's *Hydrodynamics*. By integration, the axis of the pendulum can be located and the amplitude of oscillation can be calculated for a given pendulum mass. The horizontal force is determined by a direct application of Newton's law. A relationship between the position of the center of gravity and the free surface shape is set up, and the force is calculated for a simple harmonic motion of a free surface.

**Readers' Forum: Roll to Sideslip or Yaw Ratios.** Dunstan Graham and Allan McCaskill. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, pp. 741, 742. 2 references.

**Experimental Investigation of the Effect of Vertical-Tail Size and Length and of Fuselage Shape and Length on the Static Lateral Stability Characteristics of a Model with 45° Sweptback Wing and Tail Surfaces.** M. J. Queijo and Walter D. Wolhart. *U.S., N.A.C.A., Technical Note No. 2168*, August, 1950. 59 pp., illus. 7 references.

**The Aerodynamic Forces and Moments on a $^1/_{10}$-Scale Model of a Fighter Airplane in Spinning Attitudes As Measured on a Rotary Balance in the Langley 20-Foot Free-Spinning Tunnel.** Ralph W. Stome, Jr., Sanger M. Burk, Jr., and William Bihrle, Jr. *U.S., N.A.C.A., Technical Note No. 2181*, September, 1950. 59 pp., illus. 17 references.

## WINGS & AIRFOILS

**Critical Mach Numbers for Swept-Back Wings.** S. Neumark. *Aeronautical Quarterly*, Vol. 2, Part 2, August, 1950, pp. 85–110, illus. 9 references.

The method is essentially a linear perturbation theory for thin airfoils in which the wing is replaced with an approximate continuous source-sink system, and the maximum relevant velocity, which is needed for obtaining the critical Mach Number, is determined. The maximum velocities for the entire wings, or for particular sections, are determined at zero incidence in potential incompressible flow. The method is applied to various plan forms. A biconvex airfoil section is used, but the calculation can be made for any arbitrary section. The tapered wing is considered, although it presents a more complicated solution since it requires more parameters. The critical Mach Numbers are determined by obtaining the corresponding maximum velocities for compressible flow. A series of curves give velocity distributions, the course of the isobars, and critical Mach Numbers as functions of geometric parameters.

**On the Chordwise Lift Distribution at the Centre of Swept Wings.** D. Kurchemann. *Aeronautical Quarterly*, Vol. 2, Part 2, August, 1950, pp. 146–155, illus. 1 reference.

Peculiarities of the lift distribution on swept wings. The downwash equation is developed for a swept wing of infinite span with a constant spanwise lift distribution. The downwash field of continuous distribution of swept vortex lines along the chord is needed to obtain the lift distribution at the center of the wing, but only the bound vortices are considered. This downwash differs from the two-dimensional case by a term proportional to the local vortex strength. A solution is obtained for the downwash relationship. The expression for the chordwise lift coefficient at the center involves the total lift coefficient. Solution of this expression will require further basic work since the values of the trailing vortices must be included in the calculation.

**The Profile Drag of Yawed Wings of Infinite Span.** A. D. Young and T. B. Booth. *College of Aeronautics, Cranfield, England, Report No. 38*, May, 1950. 22 pp., illus. 10 references.

The method is based on the assumption that the form of the spanwise velocity distribution in the boundary layer (either laminar or turbulent) is independent of the chordwise pressure distribution. The form is the same as that for the boundary layer of an unyawed plate with zero external pressure gradient. The boundary-layer equations and momentum integral equations for laminar and turbulent flows are developed. Experimental results indicate the reasonableness of these assumptions. The method was applied to a flat plate and a N.A.C.A. 64-012 airfoil section at zero incidence. Drag coefficient of the flat plate varies with yaw as $\cos^{1/2}\Lambda$ ($\Lambda$ = angle of yaw) for a laminar boundary layer, and as $\cos^{4/5}\Lambda$ if the boundary layer is turbulent. For the airfoil, drag coefficient varies as $\cos^{1/2}\Lambda$ for transition points between 0 and 0.5$c$, and the effect of Reynolds Number on this factor is slight.

**The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed.** C. W. Frick and R. S. Chubb. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, pp. 691–704, illus. 9 references.

**Reports on Measurements of the Pressure Distribution over a Wing of Triangular Plan Form at a Mach Number of 2.44.** G. H. Lean and K. G. Whitaker. *Gt. Brit., Aeronautical Research Council, Current Papers No. 7*, 1950 (July, 1948). 12 pp., illus. 3 references. British Information Services, New York. $0.30.

The pressure distributions obtained experimentally were compared with the theoretical values computed by linearized theory for thin flat delta wings. The experimental values give a higher pressure drag at zero incidence than to the computed values. These differences are due to lack of uniformity in the flow approaching the model and the flow in the boundary layer at the wing root. The lift coefficients are somewhat higher. Skin-friction drag is about double the pressure drag at the sides of the model.

**Transient Loading of Wide Delta Airfoils at Supersonic Speeds.** John W. Miles. *U.S., Naval Ordnance Test Station, Inyokern,*

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*Calif., Technical Memorandum No. RRB-37*, January 24, 1950. 50 pp., illus. 7 references.

Calculation using the linearized theory of the indicial admittance (the response of a linear system to the Heaviside excitation) of a pointed wing, bounded by two supersonic edges and a straight trailing edge transverse to the main flow. Formulas are derived for the lift and moment coefficients on a wide delta airfoil under conditions of sudden change in angle of attack, a uniform sharp-edged gust of unit magnitude, an impulsive gust, and a sharp-edged impulsive gust with antisymmetric linear velocity distributions over the span. The sharp-edged impulsive gust gives rise to rolling moments. The response of a two-dimensional airfoil to an impulsive gust is calculated. The results are given in curves.

**Low-Speed Characteristics of Four Cambered, 10-Percent-Thick NACA Airfoil Sections.** George B. McCullough and William M. Haire. *U.S., N.A.C.A., Technical Note No. 2177*, August, 1950. 25 pp., illus. 5 references. Two-dimensional low-speed investigation of the N.A.C.A. four-digit-series and 64A-series airfoil sections.

**Comparison of the Experimental Pressure Distribution on an NACA 0012 Profile at High Speeds with That Calculated by the Relaxation Method.** James L. Amick. *U.S., N.A.C.A., Technical Note No. 2174*, August, 1950. 9 pp., illus. 4 references.

## Air Transportation (41)

**Getting the Best from Turbine Transports.** Christopher Dykes. *Aviation Week*, Vol. 53, No. 11, September 11, 1950, pp. 21, 22, 25, 27, 28, 32, 35, illus.

Analysis of cruise-control procedures of turbine-powered transports and a comparison of these procedures with those of piston-powered craft. Tables and charts show the benefits of maintaining optimum conditions. Economic operation of turbine transports requires accurate flight planning and elaborate meteorological forecasts of temperature at high altitudes.

**Operating Problems of Turbine-Powered Aircraft.** R. D. Kelly. *Aeronautical Engineering Review*, Vol. 9, No. 10, October, 1950, pp. 28–30, illus.

**The Berlin Air Lift.** J. W. F. Merer. *Royal Aeronautical Society, Journal*, Vol. 54, No. 476, August, 1950, pp. 513–533, illus.

**United States Overseas Air Cargo Services. VI.** N. W. Kendall. *Air Transportation*, Vol. 17, No. 3, September, 1950, pp. 10, 27.

**Air Express vs. Railway Express; A Comparison of Freshness of Fishery Products. II.** William B. Lanham, Jr. *Air Transportation*, Vol. 17, No. 3, September, 1950, pp. 7, 30–32, illus.

**Proper Packaging Means Money in the Bank. II.** Bill Pringle. *Air Transportation*, Vol. 17, No. 3, September, 1950, pp. 9, 28, 29, illus.

**The Aerial Distribution of Agricultural Dressings Using the "Bristol" Type 170.** *Shell Aviation News*, No. 146, August, 1950, pp. 8–11, illus.

## Airplane Design & Description (10)

**Design for Maintenance.** R. E. Bishop. *Royal Aeronautical Society, Journal*, Vol. 54, No. 476, August, 1950, pp. 489–499, Discussion, pp. 499–512, illus.

The effects of the growing complexity of transport aircraft and high-powered reciprocating engines on maintenance. Aircraft should be designed for ease and simplicity in servicing, and the less complex gas-turbine engine, rather than the piston engine, should be used. More preinstallation testing of systems and components is necessary for increased reliability.

**The Structural and Aerodynamic Effects of Wing Thickness and Fuselage Size Variation.** A. G. Pugsley, W. Tye, and H. J. Allwright. *Gt. Brit., Aeronautical Research Council, Report and Memoranda No. 2377*, 1949 (January, 1940). 10 pp., illus. British Information Services, New York. $0.50.

**A Rocket Researcher's Reflections on Supersonic Flight.** Hermann Oberth. *Interavia*, Vol. 5, No. 7, 1950, pp. 382–385, illus. 2 references. Suggested design ideas for supersonic ramjet aircraft.

**Range of the Jets.** N. F. Silsbee. *Aviation Age*, Vol. 14, No. 3, September, 1950, pp. 32, 33, illus. Increasing the range of jet fighter aircraft through the addition of tip tanks, reducing the specific fuel consumption, and improvements in the quality of the fuel.

**What Can the Flexible Deck Do for Naval Aircraft?** Norman Macmillan. *Aircraft*, Vol. 28, No. 11, August, 1950, pp. 18, 19, 44, illus.

Results of British experiments on carrier-deck landings with flexible rubber decks and Vampire jet fighters equipped with landing skids. The method is restricted to pure jet aircraft.

### AIRPLANE DESCRIPTIONS

**Trainer Competition: Fairchild, Beech and Temco; Evaluation at Randolph AFB Will Correlate Student's Progress with Plane He Flew.** David A. Anderton. *Aviation Week*, Vol. 53, No. 9, August 28, 1950, pp. 26–28, 30, illus.

**French Private Firms Speed Comeback.** *Aviation Week*, Vol. 53, No. 12, September 18, 1950, pp. 24, 25, illus. With table of aircraft production of French private companies.

**France Pushes Plane Production.** *Aviation Week*, Vol. 53, No. 9, August 28, 1950, pp. 31–33, illus. With table showing production of French nationalized companies.

**The Italian Aircraft Industry.** *Interavia*, Vol. 5, No. 6, 1950, pp. 300–311, illus.

**Soviet Fighter History.** Denys J. Voaden. *Interservices Aircraft Recognition Journal*, Vol. 4, No. 11, July, 1950, pp. 214, 215, illus.

**British Aircraft, 1950.** *Flight*, Vol. 58, No. 2176, September 7, 1950, pp. 265–280, illus. Descriptions and specifications of civil and military aircraft.

**Another Farnborough Triumph.** *Flight*, Vol. 58, No. 2177, September 14, 1950, p. 287.

Descriptions and photos of aircraft exhibited at the Society of British Aircraft Constructors Display at Farnborough, September, 1950. Includes descriptions and specifications of power plants and accessories in the static display.

**Aerocar (Taylor) Roadable Airplane.** Moulton B. Taylor. *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 26, 81, 82, illus.

**Airspeed Ambassador Twin-Engined Transport, England.** Peter Masefield. *de Havilland Gazette*, No. 58, August, 1950, pp. 2–4, illus.

Scheduled air-line operation of the Airspeed Ambassador; analysis of possible routes for the Ambassador; and a comparison of its operating costs with those of the Dakotas now in use on B.E.A. routes. In revenue earnings per ton-mile, the Ambassador is expected to be 19 per cent cheaper to operate than the Dakota.

**Blackburn & General Universal Freighter, England.** *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 44, 45, 97, 98, illus.

**Burnelli CB-8 Turboprop "Lifting Body" Transport.** *Aviation Operations*, Vol. 14, No. 2, August, 1950, pp. 22, 23, illus.

**de Havilland Comet Turbojet Transport, England.** *de Havilland Gazette*, No. 58, August, 1950, pp. 16–19, illus. Operational aspects.

**de Havilland Heron 4-Engined Transport, England.** *de Havilland Gazette*, No. 58, August, 1950, pp. 32, 33, illus. Performance economics.

**Fairchild XC-120 Packplane Cargo Transport.** *Aviation Week*, Vol. 53, No. 11, September 11, 1950, pp. 16, 17, illus.

**Hurel-Dubois High-Aspect-Ratio Monoplane, France.** Georges Bruner. *The Aeroplane*, Vol. 79, No. 2045, August, 18, 1950, pp. 187–191, illus.

**Junkers Ju. 287 Turbojet Swept-Forward-Wing Bomber, Germany.** *Interavia*, Vol. 5, No. 7, 1950, pp. 380–382, illus.

**McDonnell XF-88 Turbojet Fighter.** *Aviation Week*, Vol. 53, No. 10, September 4, 1950, pp. 27–29, 33, illus.

**MG-9 Turbojet Fighter, U.S.S.R.** *Interservices Aircraft Recognition Journal*, Vol. 4, No. 11, July, 1950, p. 207, illus.

**Saab 29 Turbojet Fighter, Sweden (Aviation Design Progress).** *Aviation Age*, Vol. 14, No. 3, September, 1950, pp. 24, 25, cutaway drawings.

**Swift 125 Two-Place Airplane (Aviation Design Progress).** *Aviation Operations*, Vol. 14, No. 2, August, 1950, pp. 24, 25, cutaway drawings.

**Vickers Viscount 700 Turboprop Transport, England.** *Flight*, Vol. 58, No. 2176, September 7, 1950, pp. 281–283, cutaway drawing.

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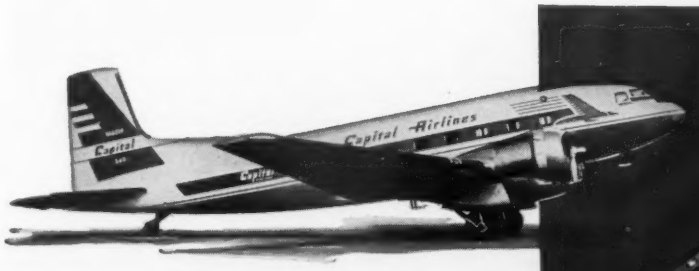

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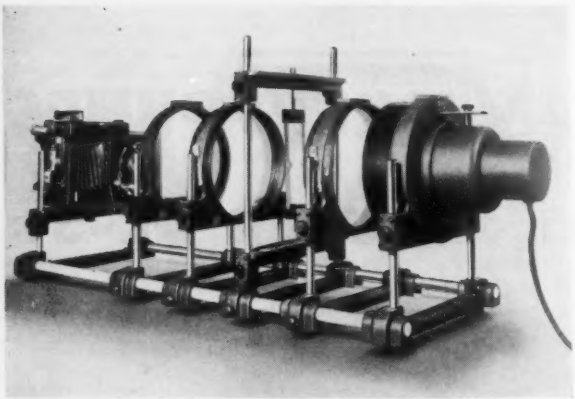

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### CONTROL SYSTEMS

**"Look . . . Hands and Feet!"** Jacques Lecarme. *Interavia*, Vol. 5, No. 7, 1950, pp. 375–379, illus. Light-plane and helicopter control systems; piloting problems involved.

### FUEL TANKS

**The Forces Produced by Fuel Oscillations in a Rectangular Tank.** E. W. Graham. *Douglas Aircraft Company, Inc., Report No. SM-13748*, April 13, 1950. 14 pp., illus. 1 reference.

Mathematical study of the effect on airplane dynamic stability of small sinusoidal fuel oscillations in a stationary rectangular tank. The fuel is replaced by a simple pendulum with a fixed mass, and the equivalent simple pendulum is determined. The pressure distribution in the tank and the frequency of the wave motion are obtained from Lamb's *Hydrodynamics*. By integration, the axis of the pendulum can be located and the amplitude of oscillation can be calculated for a given pendulum mass. The horizontal force is determined by a direct application of Newton's law. A relationship between the position of the center of gravity and the free surface shape is set up, and the force is calculated for a simple harmonic motion of a free surface.

### LANDING GEAR

**The Development of Anti-Skid Braking.** Gordon W. Yarber. *Applied Hydraulics*, Vol. 3, No. 8, September, 1950, pp. 25–27, illus.

Automatic braking system developed by the Boeing Airplane Co. to enable any pilot to make short landing rolls consistently without damaging the tires. The device employs a "skid detector," which is a fairly simple mechanism that uses flywheel inertia to detect the rate of change of wheel speed in excess of that met in maximum nonskid braking. The electrical control system holds the brakes released from each wheel independently until it contacts the runway and is accelerated to a high speed. The automatic skid control prevents excessive brake pressures and keeps the wheels rotating at close to nonskid speed while the aircraft is brought to a fast stop. The apparatus was subjected to both a test-rig and flight tests.

### WINDSHIELDS

**Heat Transfer from an Air Jet to a Plane Plate with Entrainment of Water Vapor from the Environment.** Max Jakob, R. L. Rose, and Maurice Spielman. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 859–867, illus. 12 references.

## Airports (39)

**An Investigation into Air Traffic Control by a Simulation Method.** R. B. Coulson and V. D. Burgmann. *Australia, Commonwealth Scientific and Industrial Research Organization, Division of Radiophysics, Report No. RPR113*, March, 1950. 56 pp., illus. 11 references.

Investigations of air-traffic control problems by simulation methods with specially developed laboratory equipment, and a detailed study of the efficiency and safety of several possible control systems. Simulation of the two-course radio-range system now in use in Australia gave results that compared well with actual operations. Reducing the minimum height of the stack or aligning the radio range with the runway gives marked improvement. An orbiting approach procedure increased airport capacity but required excessive attention from the controller. Airport capacity can be further improved with the Multiple-Track Range and D.M.E. by using both lateral and height separation of aircraft. Specific minimum separations between landings cannot always be adhered to. Unnecessary delays, which depend upon the controller's efficiency and the pilot's ability to report his position accurately and to follow directions, cause slow-ups in the traffic pattern. The type and performance of the navigation aids installed affect airport capacity.

**Jets and Air Traffic Control. II, III.** John Longhurst. *The Aeroplane*, Vol. 59, Nos. 2045, 2046, August 18, 25, 1950, pp. 195–198; 222–224; illus.

II. Factors to be considered in establishing alternate airports; problems involved in mixed traffic of jet and piston-engine aircraft; and suggested flow-control procedures to eliminate stack-

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ing at the arrival airport. **III.** Improvements in air-traffic control, including use of radar, need for jet transports; and reduction of unnecessary delays on the ground if a fast schedule is to be kept.

**Siting of Landing Strips for International Aircraft Movements in Great Britain.** William Courtenay. *Royal Aeronautical Society, Journal*, Vol. 54, No. 476, August, 1950, pp. 541–543.

**Planning Your Airport Transformer Vault.** L. C. Vipond. *Aviation Age*, Vol. 14, No. 3, September, 1950, p. 30, illus.

## Aviation Medicine (19)

**Visibility of Cockpit Instruments.** Norman Lee Barr. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 10, October, 1950, pp. 26–32, illus. 1 reference.

Visual problems brought about by high-altitude flight and suggested remedies of these conditions. Instruments have decreased in size and increased in number. The brightness contrast between the cockpit and the surrounding area (sky, terrain, etc.) makes it difficult for pilots to obtain a focus on the panel quickly. The amount of illumination practical for sea-level daylight conditions is inadequate for high-altitude daylight work. The design of cockpit instrument dials must sufficiently exceed the fundamental visual threshold values to ensure ease of focusing and reading the instruments.

**Visibility of Cockpit Instruments.** Norman Lee Barr. *Journal of Aviation Medicine*, Vol. 21, No. 4, August, 1950, pp. 328–342, 346, illus. 1 reference.

**A Study of the Legibility of Trans-Illuminated Markings in Aircraft Cockpits. II.** Fred R. Brown. *U.S., Naval Air Material Center, Philadelphia, Naval Air Experimental Station, Report TED No. NAM EL 600*, February 25, 1949. 33 pp., illus. 11 references.

**Eye Fixations of Aircraft Pilots. V—Frequency, Duration, and Sequence of Fixations When Flying Selected Maneuvers During Instrument and Visual Flight Conditions.** John L. Milton, Richard E. Jones, Paul M. Fitts, and William G. Morris. *U.S., Air Force, Technical Report No. 6018*, August, 1950. 33 pp., illus. 5 references.

**A Study of the Moving Figure and Orientation of Symbols on Pictorial Aircraft Instrument Displays for Navigation (Human Engineering Systems Studies).** Thomas A. Payne. (University of Illinois, Department of Psychology.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 71-16-6*, July 11, 1950. 25 pp., illus. 7 references.

**Motion Sickness.** Fred Harbert. *United States Armed Forces Medical Journal*, Vol. 1, No. 9, September, 1950, pp. 979–984. 6 references.

**Problems on Parachute Jumps over the Andes.** Guillermo Garrido-Lecca Frias. *Journal of Aviation Medicine*, Vol. 21, No. 4, August, 1950, pp. 343–346. 13 references.

**Effect of Repeated Exposure of Human Subjects to 18,000 Feet Without Supplemental Oxygen, to Hyperventilation, and to 35,000 Feet with 100 Per Cent Oxygen for One Hour, on Ascorbic Acid Excretion and Plasma Level on Urine pH.** L. R. Krasno, J. H. Cilley, J. H. Boutwell, A. C. Ivy, and C. J. Farmer. *Journal of Aviation Medicine*, Vol. 21, No. 4, August, 1950, pp. 283–292, 312, illus. 13 references.

**Extent of Pathological Damage to Animals Explosively Decompressed in a Cold Environment.** William L. Burkhardt, Robert E. Hedblom, A. W. Hetherington, and H. F. Adler. *Journal of Aviation Medicine*, Vol. 21, No. 4, August, 1950, pp. 304–308, 320, illus. 7 references.

**Performance Under Acute Hypoxic Stress in Acclimatized Mice.** Rudolph E. Wilhelm, Morton S. Comess, and John P. Marbarger. *Journal of Aviation Medicine*, Vol. 21, No. 4, August, 1950, pp. 313–317, illus. 11 references.

**Cardiovascular Pressor Reflex Mechanism and Cerebral Circulation Under Negative G Head-to-Tail Acceleration.** Sheldon Rosenfeld and Charles F. Lombard. *Journal of Aviation Medicine*, Vol. 21, No. 4, August, 1950, pp. 293–303, 354, illus. 16 references.

**Evaluation of Present-Day Knowledge of Cosmic Radiation at Extreme Altitude in Terms of the Hazard to Health.** Hermann J. Schaefer. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 10, October, 1950, pp. 21–26, illus.

**Effects of Intense Microwave Radiation on Living Organisms.** John W. Clark. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1028–1032, illus. 9 references.

**The New Medical Service of the United States Air Force.** Harry G. Armstrong. *Journal of Aviation Medicine*, Vol. 21, No. 4, August, 1950, pp. 318–320.

**"Basic English" for Aviation.** James H. Winchester. *Aviation Age*, Vol. 14, No. 3, September, 1950, pp. 26, 27, illus. Studies by the C.A.A. and other organizations to formulate a standard "pilot's" vocabulary for radio communication, which would eliminate unintelligible, confusing words and phrases.

**Further Attempts to Demonstrate Interference in the Performance of Rotary Pursuit Tasks (Human Engineering Synthesis of Basic Information).** James L. Hedlund and Don Lewis. (State University of Iowa.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 938-1-3*, June 27, 1950. 11 pp., illus. 14 references.

**The Effects of Alternating Practice on the Performance of Two Antagonistic Motor Tasks (Human Engineering Synthesis of Basic Information).** Walter Spieth and Don Lewis. (State University of Iowa.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 938-1-6*, July 26, 1950. 9 pp., illus. 2 references.

**Studies in Complex Coordination. I—Performance on the Two-Hand Coordinator As a Function of the Planes of Operation of the Controls. (Human Engineering System Studies).** Eugenia B. Norris and S. D. S. Spragg. (University of Rochester, Department of Psychology.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 241-6-3*, August, 1950. 15 pp., illus. 9 references.

**A Study of Warmup Decrement in Pursuit Rotor Performance (Human Engineering Synthesis of Basic Information).** Jack A. Adams. (State University of Iowa.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 938-1-5*, July 18, 1950. 19 pp., illus. 16 references.

**Prior Learning As a Factor in Shaping Performance Curves (Human Engineering Synthesis of Basic Information).** Alfred H. Shephard and Don Lewis. (State University of Iowa.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 938-1-4*, July 11, 1950. 9 pp., illus. 2 references.

## Comfortization (23)

**Passenger Seats for Aircraft.** C. H. Cumberland and G. S. Bowey. *Aircraft Engineering*, Vol. 22, No. 259, September, 1950, pp. 250–255, illus. 4 references.

Recommendations for a satisfactory aircraft seat design based on anatomical and physiological studies of the human body, with consideration of the weight limitations and strength requirements of the seats. Tables list suggested seat dimensions, as well as seat pitch and weight classification. Each seat must have a favorable appearance and must not suggest any insecurity or danger to the passenger. Seat coverings should be lightweight, durable, and easily cleaned. Added protection must be afforded to passengers by the adoption of backward-facing seats.

**Hamilton Standard Air Conditioning.** *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 62, 96, illus.

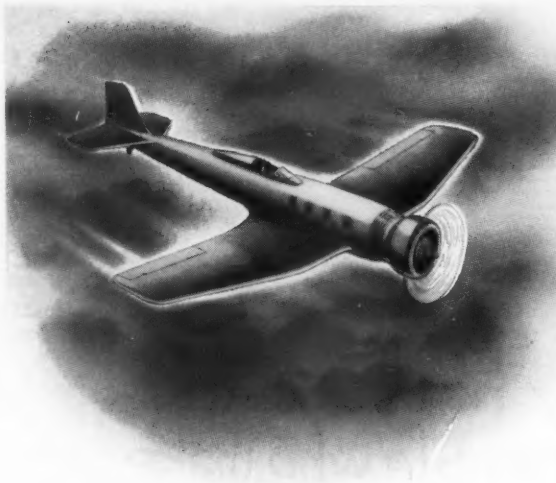
**Equipment for Cabin Pressurization. The "Stratos" Replacement.** William Friedman. **Hydraulic Drive for Cabin-Compressor System.** Harrison W. Holzapfel. *Aero Digest*, Vol. 61, No. 3, September, 1950, 38, 39, 82–84, illus.

**British, U.S. Cabin Blowers Evaluated; TCA Installs Godfrey Superchargers in Its Fleet of North Stars; Stratos Units Go into RCAF's C-5.** *Aviation Week*, Vol. 53, No. 11, September 11, 1950, pp. 40, 43, illus.

**High-Density Conversions Prove Worth; Alteration of DC-6s and Connies for Coach Service Effected at Moderate Cost.** Irving Stone. *Aviation Week*, Vol. 53, No. 10, September 4, 1950, pp. 20–22, illus.

## Education & Training (38)

**Air Age Education.** Frederick B. Tuttle. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 259–268. 2 references.



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This airplane looked different—*was* different. The Boeing "Monomail" was America's first low-wing, all-metal commercial plane to be truly streamlined. It had a smooth skin of Alcoa Aluminum, with countersunk rivets to reduce drag. The revolutionary semi-monocoque construction employed aluminum alloys, too, for longerons, stiffeners, bulkheads, wing panels, spars and ribs. It was a big jump toward today's standards!

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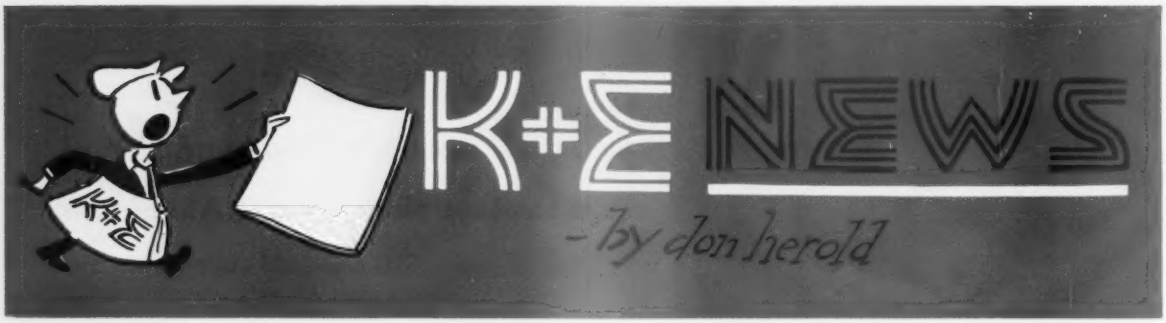

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At Keuffel & Esser precision and quality are almost a century plant. In other words they have been growing there in fertile soil for exactly 83 years. (K&E was founded in 1867.)

It's mostly a matter of people. Oh, there are machines, too, big ones, little ones—some of them almost human—but it takes people to imagine the machines, and to master them and supplement them.

## Precision in the Air

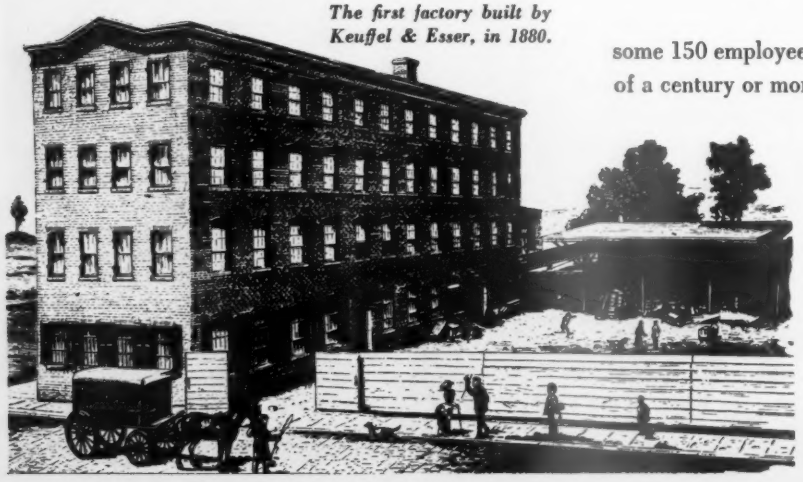
I've been talking about K&E products for a long, long time. Maybe it's time I talked a little about the people behind them.

I've just been through the K&E factory at Hoboken again. I wish you could have been along, because you, as an engineer, would have seen much more than I. But even I could sense the honest craftsmanship and the father-and-son tradition of precision and the zeal for quality in the air.

You just don't get to be that fine in one generation.

There are a number of K&E employees who have been around for about a half a century, and there are some 150 employees who have been there for a quarter of a century or more. This latter bunch of kids, as well as the young sprouts who have been there only 20 or 15 years, have inherited the K&E feeling for doing things the good, old, exciting, honest way.

But don't get the idea that there is any moss on K&E. An outfit that has thrived this long has to have the knack of remaining perennially young and of keeping ahead of the pack.



*The first factory built by Keuffel & Esser, in 1880.*

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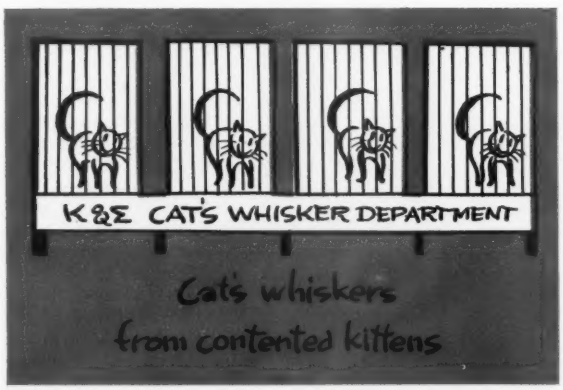
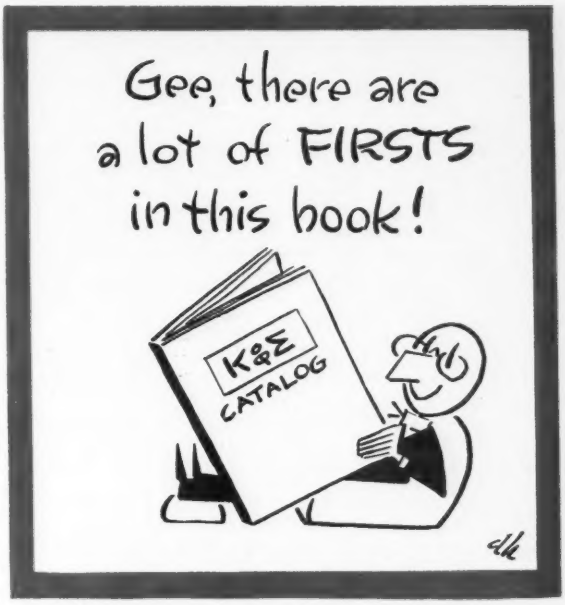
## Zippy at 83

K&E have remained alert and alive, as is evidenced by their unending originality and inventiveness. They made America's first slide rules, as far back as 1891. And in both world wars, they did a big development job on optical equipment for our fighting men—on vital things such as periscopes, fire control instruments and height finders. The K&E catalog is full of "firsts"—some of them plenty recent, such as Wyteface* Measuring Tapes and Leroy† Lettering Equipment. No wonder it's the engineers' encyclopedia.




## Factories within a Factory

K&E headquarters are a town within a town, many factories within a factory. In one area they're coating miles of papers and cloths. In another they're turning screws so tiny you feel like a hippopotamus if you try to pick one up. Here they're grinding optical lenses.




There they're putting graduations no bigger than a fly's kneecap on scales of some sort. Here they're doing fastidiously fine leather work. There they're reeling off steel measuring tapes by the mile.

K&E was in there, sighting, in World Wars I and II

But wherever you go you are aware of the age-old passion for precision and quality. And I'm not the least bit sorry that today I haven't sold you a single K&E product. I've just tried a little bit to sell you on the people at K&E—and to get you to believe that you can safely make K&E products trusted partners in your own creative work.

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## Electronics (3)

**Selective Mixing Amplifier for Aircraft.** Paul B. King, Jr. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 100, 101, illus.

The Aircraft Radio Corporation F-11 dual-output isolation amplifier, which permits independent selection of one to ten audio channels by pilot and copilot, independent choice of range-voice filters on two circuits and independent muting of receivers, and choice of speaker or headphone operation. Fail-safe relays (normally energized when equipment is in use) drop out and bypass amplifier in the case of component failure.

**Some Experiments on the Accuracy of Bearings Taken on an Aural-Null Direction-Finder.** F. Horner. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 359–361, illus.

**Discussion on "The Relative Merits of Presentation of Bearings by Aural-Null and Twin-Channel Cathode-Ray Direction-Finders" and "Some Experiments on the Accuracy of Bearings Taken on an Aural-Null Direction-Finder."** *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 362–365.

**German Radiolocation in Retrospect.** L. Brandt. *Interavia*, Vol. 5, No. 6, 1950, pp. 315–321, illus.

**Radio Control of Model Boat.** William L. North. *Radio & Television News*, Vol. 44, No. 2, August, 1950, pp. 29–33, illus., circuit diagrs. The system is adaptable to the control of model aircraft.

**Polyphase Modulation As a Solution of Certain Filtration Problems in Telecommunication.** I. F. MacDiarmid and D. G. Tucker. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 349–358, illus. 30 references.

**Factors Governing the Radiation Characteristics of Dielectric Tube Aerials.** D. G. Kiely. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 311–321, illus. 15 references.

**Pattern Calculations for Antennas of Elliptical Aperture.** R. J. Adams and K. S. Kelleher. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, p. 1052, illus.

**Radiation from Circular Current Sheets.** W. R. Lepage, C. S. Roys, and S. Seely. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1069–1072, illus. 6 references.

**Reflection and Transmission of Electromagnetic Waves by Thin Curved Shells.** Joseph B. Keller. *Journal of Applied Physics*, Vol. 21, No. 9, September, 1950, pp. 896–901. 9 references.

**Microwave Lenses. I.** J. Brown and S. S. D. Jones. *Electronic Engineering*, Vol. 22, No. 271, September, 1950, pp. 358–361, illus. 8 references.

**Development of Artificial Microwave Optics in Germany.** Otmar M. Stuetzer. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1053–1056, illus. 8 references.

**Some Perturbation Effects in Cavity Resonators.** A. Cunliffe and L. E. S. Mathias. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 367–376, illus. 8 references.

**Voltage Regulation for Higher Fidelity.** J. Carlisle Hoadley. *Radio & Television News*, Vol. 44, No. 2, August, 1950, pp. 47–50, illus.

**Experimental Magnetic-Type D.C.-A.C. Signal Inverter.** James Kauke. *Radio & Television News*, Vol. 43, No. 5, May, 1950, pp. 64, 65, 155, illus.

**Small-Signal Theory of Wave Propagation in a Uniform Electron Beam.** G. G. MacFarlane and A. M. Woodward. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 322–328, illus. 8 references.

**Long-Life Tubes for Industry.** Elwood K. Morse. *Electronics*, Vol. 23, No. 9, September, 1950, pp. 68, 69.

**A Thermal Millivoltmeter for Measuring Radio-Frequency Voltages.** N. Coulson. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 344–348, illus.

**An Amplifier for Magnetic Oscillographs.** C. J. Tirk. *Westinghouse Engineer*, Vol. 10, No. 3, May, 1950, pp. 146, 147, illus., circuit diagr. A three-stage amplifier with an input impedance of 10 megohms.

**Low Frequency Generator.** W. G. Shepard. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 116, 118, illus. Schematic diagram and description of a multivibrator sine-wave generator producing frequencies from 0.2 to 100 cycles.

**On Certain Matters Pertaining to Electrets.** W. F. G. Swann. *Franklin Institute, Journal*, Vol. 250, No. 3, September, 1950, pp. 219–248, illus. 20 references.

**Investigations into Tropic Proofing of Electrical Materials, 1943–1946. I—The Protection of Electronic Equipment for Use Under Humid Tropical Conditions.** L. G. Dobbie. **II—The Influence of Moisture on Insulating Materials.** J. S. Dryden and P. T. Wilson. **III—Some Experiments on the Application of Organosilicon Compounds to Glass and Ceramic.** R. J. Meakins, Joan W. Mulley, and Vivienne R. Churchward. **IV—The Treatment of Glass and Steatite Ceramic with Quaternary Ammonium Compounds.** R. J. Meakins. **V—The Corrosion of Copper Wires at D.C. Potential in Contact with Electrical Insulating Materials.** R. J. Meakins. *Australian Journal of Applied Science*, Vol. 1, No. 1, March, 1950, pp. 80–132, illus. 78 references.

**An L-C-Q Meter.** Wm. K. Brookshier. *Radio & Television News*, Vol. 43, No. 4, April, 1950, pp. 67–70, 153, illus.

**The Electronic Switch.** Victor Beckstrom. *Radio & Television News*, Vol. 43, No. 4, April, 1950, pp. 38–40, illus.

**A 100 Kc. Square-Wave Generator.** Louis E. Garner. *Radio & Television News*, Vol. 44, No. 2, August, 1950, pp. 44, 45, illus.

**Two Standard Field-Strength Meters for Very-High Frequencies.** D. D. King. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1048–1051, illus. 12 references.

**Metallized Paper Capacitors.** John H. Fisher. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 122, 214, 218, 220, 222, illus.

**Metallized Paper for Capacitors.** D. A. McLean. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1010–1014, illus. 5 references.

**Metallized Paper Capacitors.** J. R. Weeks. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1015–1018, illus. 3 references.

**The Structural, Electrical Properties and Potential Applications of the Barium-Titanate Class of Ceramic Materials.** Willis Jackson. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 285–289, illus. 75 references.

**High-Frequency Vibrations of Plates Made from Isometric and Tetragonal Crystals.** E. A. Gerber. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1073–1078, illus. 18 references.

**A Fast Sweep Circuit.** N. L. Davis and R. E. White. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 107–109, illus.

An oscilloscope designed for the study of extremely short-duration phenomena. It has a uniform frequency response to 265 megacycles. Either single or recurrent traces can be observed to a repetition rate of 5,000 cycles. Maximum sweep is 100 in. per microsecond, several sweep ranges reaching a maximum length of 25 microseconds. Sweep voltage is generated by a hydrogen thyratron circuit. Three calibration methods were tried, the most accurate consisting of the use of a crystal-controlled transmitter as a timing-wave source.

**Precision A.C. Voltage Stabilizers. I.** G. N. Patchett. *Electronic Engineering*, Vol. 22, No. 271, September, 1950, pp. 371–377, illus. 35 references.

**The Klystron Mixer Applied to Television Relaying.** Vincent Learned. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1033–1035, illus. 4 references.

**The Compensation of Delay Distortion in Video Delay Lines.** R. A. Erickson and H. Sommer. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1036–1040, illus. 8 references.

**Integration Noise Reducer for Radar.** W. J. Cunningham, J. C. May, and J. G. Skalnik. *Electronics*, Vol. 23, No. 9, September, 1950, pp. 76–78, illus. 8 references.

**Distribution in Energy of Johnson Noise Pulses.** Ben R. Gossick. *Journal of Applied Physics*, Vol. 21, No. 9, September, 1950, pp. 847–850, illus. 13 references.

**A Subjective Method of Measuring Radio Noise.** H. A. Thomas. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 329–334, illus. 11 references.

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**The Poynting Vector in the Ionosphere.** James C. W. Scott. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 9, September, 1950, pp. 1057–1068, illus. 11 references.

**Solar Radio-Frequency Radiation.** J. L. Pawsey. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 290–310, illus. 66 references.

**Some Measurements of Atmospheric Noise at High Frequencies.** H. A. Thomas. *Institution of Electrical Engineers, Proceedings, Part 3, Radio and Communication Engineering*, Vol. 97, No. 49, September, 1950, pp. 335–343, illus. 16 references.

**Electronic Inspection of Engine Cam Contours.** Michael G. Turkish. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 74–77, illus.

With the camshaft mounted in a lathe, the cam pushes a rod-shaped permanent magnet back and forth inside a pickup coil to generate voltage proportional to velocity, which appears as curves of lift, velocity, and acceleration. Circuit diagrams and details of component parts are given. The apparatus can be applied to testing engine-valve motion at high speeds.

## Engineering Practices (49)

**"Pattern" Cutting Curves for Inflatable Dinghies; An Analytical Method for Developing the Gores for the Buoyancy Chamber and the "Floor" Contour of Pneumatic Dinghies.** J. Morris. *Aircraft Engineering*, Vol. 22, No. 259, September, 1950, pp. 278, 279, illus.

## Equipment

### ELECTRICAL (16)

**24-Volt D-C Aircraft Electrical Systems.** J. D. Miner and B. O. Austin. *Westinghouse Engineer*, Vol. 10, No. 5, September, 1950, pp. 212–216, illus. 3 references.

Advances and improvements in performance and reliability of the 24-volt d.c. aircraft electrical system have extended its application to all but the heaviest military requirements. The parts of the system and their functions are examined. The "package system," which has the control components assembled into a compact unit (as used on the Martin 2-0-2), is discussed.

**Electric Machines of High Power-Weight Ratio.** H. Lanoy. (*Revue de l'Aluminium*, Vol. 27, No. 164, March, 1950, pp. 109–112.) *Engineers' Digest*, Vol. 11, No. 8, August, 1950, pp. 276, 277, illus.

Weight reduction in aircraft electric generators through improved production techniques, better lubricants and bearings, and the use of light aluminum alloys and extra-light magnesium alloys.

### HYDRAULIC & PNEUMATIC (20)

**Transitional Friction Effects in Powered Controls with Particular Reference to Hydraulic Jacks.** F. Holoubek. *Gt. Brit., Aeronautical Research Council, Current Papers No. 12*, 1950. 29 pp., illus. 3 references. British Information Services, New York. $0.50.

Analysis of a system in which power is transmitted from a constant-rate source into an output component of finite mass through an elastic medium in which the output element is restrained by friction. The resulting motion of the mass is of an incremental nature, with a period of rest between cycles of sustained amplitude, marked by the difference between the static and kinetic values of the friction. This response is noticeable in the case of a rubber-metal combination, such as a hydraulic jack. The equations of motion for this system are developed. The response, which is quasi-oscillatory and consists of a succession of jerks in the general direction of motion, is referred to as "judder." Severity of this action may be lessened by increasing the frequency of the system through a stiffening of the transmitting medium. Jack friction should be kept generally low, and the combination of rubbing materials and fluids with large differences between static and kinetic friction coefficients should be avoided.

**Synthetic Hydraulic Fluids.** C. M. Murphy and W. A. Zisman. *Product Engineering*, Vol. 21, No. 9, September, 1950, pp. 109–113, illus.

Comparison of new types of hydraulic fluids with modified petroleum hydraulic oils; chief consideration was flammability. The fluids were subjected to laboratory and incendiary flammability tests. No available petroleum-base or caster-oil-base fluid is sufficiently flame resistant, and the addition of high concentrations of antioxidants did not improve the flame resistance. The most serious fire hazard found is the ignition of a fog or mist of the fluid in the air, which can cause a serious explosion. Relative viscosity, operation at high and low temperatures, volatility, effect on seals and rings, and the effect on metals were also considered. Other fluids tested include advanced types of the conventional hydraulic fluids, diesters, polyglycols and polyglycol derivatives, silicones, fluids with a high phosphorous content, halogenated fluids, completely fluorinated hydrocarbons, and water-base fluids.

**Hydraulics; A Brief History, Together with an Appraisal of the Present State of the Art and a Survey of Future Trends.** C. B. Bailey-Watson. *Flight*, Vol. 58, No. 2173, August 17, 1950, pp. 191–196, illus.

**Frictional Characteristics of O-Rings with a Typical Hydraulic Fluid.** L. E. Cheyney, W. J. Mueller, and R. E. Duval. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 3, April, 1950, pp. 291–297, illus. 11 references.

**Needle Bearings in Pump Design.** B. T. Virtue and R. H. White. *Applied Hydraulics*, Vol. 3, No. 8, September, 1950, pp. 21, 50, 54, illus.

**How to Choose the Proper Packing.** H. C. Matheis. *Applied Hydraulics*, Vol. 3, No. 8, September, 1950, pp. 22–24, 53, illus.

## Flight Operating Problems (31)

### CLIMATIZATION

**Some Tricks in Cold Weather Operations.** J. T. Dyment. (*S.A.E. Annual Meeting, Detroit, January 9–13, 1950.*) *Esso Air World*, Vol. 3, No. 1, July-August, 1950, pp. 9–13, 16, illus. 1 reference.

### WEATHER HAZARDS

**Operational Feasibility of Aircraft Through Thunderstorms.** L. C. Kappil. *Aeronautical Engineering Review*, Vol. 9, No. 10, October, 1950, pp. 18–27, illus.

## Flight Safety & Rescue (15)

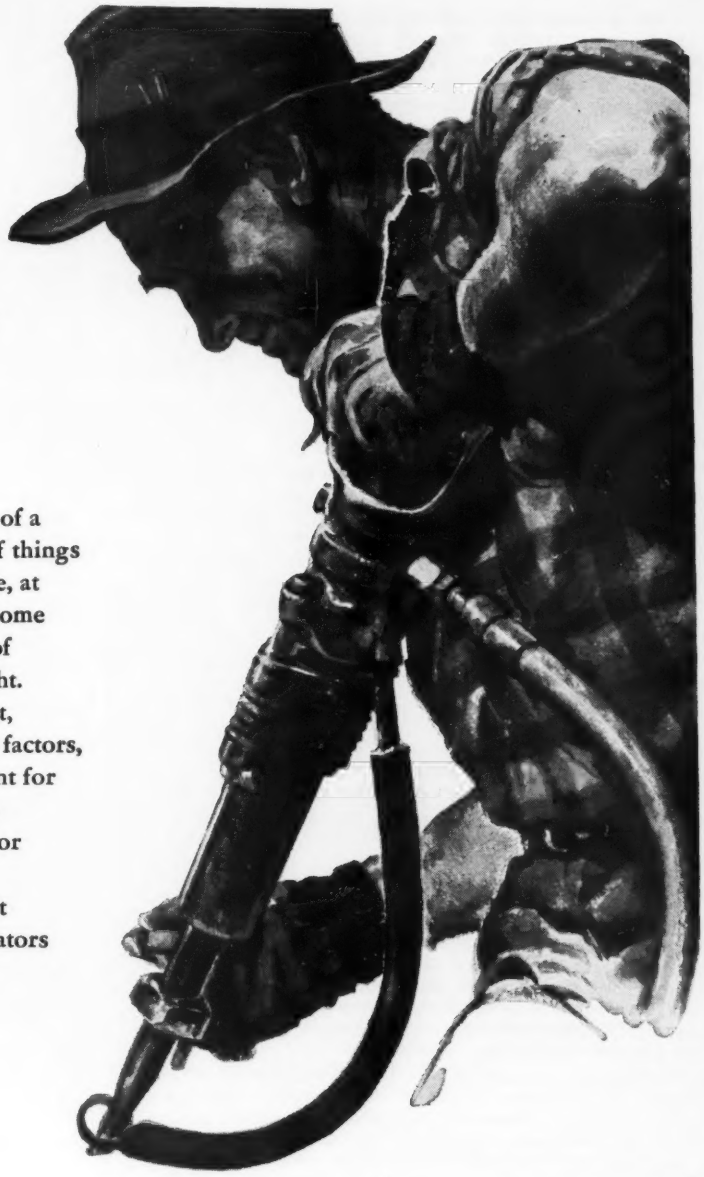
**Some Aspects of Air Safety.** C. H. Jackson. *Royal Aeronautical Society, Journal*, Vol. 54, No. 477, September, 1950, pp. 587–601, illus.

Trends in air safety in air-line operation. The aircraft manufacturers should build aircraft to better safety standards: relief from structural failures; design for stability and control; and instrument, cockpit, and cabin layouts that give more efficient and dependable operation. An analysis of accident records indicates the need for extensive training of fl ght crews to lessen the danger of operational misjudgment. The use of the "flight simulator" would aid in crew training. Agreement has been reached on what type of landing and navigation aids should be developed and standardized. The joint target of manufacturer and operator is to ensure, through good aircraft design and adequate operational equipment, that dangers do not arise.

**Investigation of Fires Originating in Aircraft Vacuum Systems.** J. J. Gassmann. *U.S., Civil Aeronautics Administration, Technical Development Report No. 67*, May, 1950. 12 pp., illus.

Tests on an operating vacuum system to determine the effects of blockage of the suction or pressure lines combined with malfunctioning of the suction or pressure relief valves and whether these conditions could cause fire within the system. Tests were conducted on the vacuum system installed in the engine of the B-29 under simulated flight conditions to provide data for a bench tests apparatus that would reproduce in-flight internal fire conditions. A comparison was made between vacuum piping systems in use and proposed systems to determine their relative abilities to withstand internal fire. Recommendations were presented for reducing the fire hazards present and for developing fire-retardant systems.

**Recommended Good Practices to Safeguard Against the Fire Hazards of Static Electricity in Aircraft Operations and Maintenance, 1950.** *National Fire Protection Association, Boston, Pamphlet No. NFPA 404* (*Formerly Aviation Bulletin No. 14*), June, 1950. 12 pp. 30 references.



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- PNEUMATIC FUSES

**Use of Aircraft Accident Investigation Information in Actions for Damages.** John W. Simpson. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 283–291.

**Built-In Safety for Transports.** Charles Adams. *Aviation Week*, Vol. 53, No. 12, September 18, 1950, pp. 44–46, illus. Problems involved in building safety into new transports; C.A.B. proposals to increase safety.

**Extension Lights & Expansion Bags.** Jerome Lederer. *Aero Digest*, Vol. 61, No. 3, September, 1950, p. 33, illus.

**About Aviation Insurance. II, III.** Joseph M. Chase. *Aviation Operations*, Vol. 14, Nos. 2, 3, August, September, 1950, pp. 42, 43; 74, 75; illus.

## Flight Testing (13)

**Aircraft Flight Testing in Miniature.** J. E. Murphy and M. V. Morkovin. *Aeronautical Engineering Review*, Vol. 9, No. 10, October, 1950, pp. 31, 32, 35, illus.

## Fuels & Lubricants (12)

**Application of White Fuming Nitric Acid and Jet-Engine Fuel (AN-F-58) as Rocket Propellants.** M. J. Zucrow and C. F. Warner. *American Rocket Society, Journal*, No. 82, September, 1950, pp. 139–150, illus. 12 references.

Use of WFNA-(AN-F-58) liquid propellant should give results similar to WFNA-aniline. The ignition system can be developed along conventional lines, with no unusual problems foreseen. Regenerative cooling is practical in the motor up to a combustion pressure of approximately 2,000 lbs. per sq.in., but, in the nozzle throat, only to about 1,200 lbs. per sq.in. Above that combustion pressure, other cooling methods must be tried. Heat-transfer processes between the hot gases and the metal walls are considered, but more research is needed before this question can be definitely solved. Film cooling is practical since a stable film flow can be built up along the walls.

**The Emission of Radiation from Nitric Oxide: Approximate Calculations.** L. E. Benitez and S. S. Penner. *Journal of Applied Physics*, Vol. 21, No. 9, September, 1950, pp. 907, 908, illus. 4 references.

**Aircraft Turbine Engine Fuel Requirements.** E. A. Droegemueller. *Standard Oil Company of California, Aviation Division, Commercial Aircraft Turbine Engine Fuel and Lubricant Symposium, Los Angeles*, July 11, 1950. 23 pp., illus.

Advantages of a distillate fuel of the kerosene type for gas-turbine engines. The relatively high viscosity and low volatility of this type of fuel have considerable advantages in relation to the permissible range of turbine-powered aircraft. Specifications of six proposed turbine fuels are tabulated.

**Performance Characteristics of Commercial Aircraft Turbine Fuels.** J. D. Rogers. *Standard Oil Company of California, Aviation Division, Commercial Aircraft Turbine Engine Fuel and Lubricant Symposium, Los Angeles*, July 11, 1950. 10 pp., illus.

A comparison. A distillate of the kerosene or stove-oil type can best fulfill the overall characteristics of a commercial jet fuel. Several petroleum fuels can be made to perform efficiently if the gas-turbine design has been developed for use with the particular fuel.

**Economic Aspects of a Wide Variety of Possible Commercial Aircraft Turbine Engine Fuels.** W. V. Hanley. *Standard Oil Company of California, Aviation Division, Commercial Aircraft Turbine Engine Fuel and Lubricant Symposium, Los Angeles*, July 11, 1950. 7 pp.

Consideration of fuel costs. Earlier use of turbine-powered aircraft would be assured if large savings in fuel and operational costs could be realized by the use of less costly grades of heavier fuels, such as kerosene and stove oil. Commercial aircraft turbines in the development stage should be adapted to existing low-cost fuels without sacrificing performance efficiency and reliability.

**Lubrication Problems of Commercial Aircraft Turbines.** J. M. Stokely and J. G. Carroll. *Standard Oil Company of California, Aviation Division, Commercial Aircraft Turbine Engine Fuel and Lubricant Symposium, Los Angeles*, July 11, 1950. 11 pp.

Problems result from combinations of two or more of the following factors: low temperature, high temperature, high rotative speeds, high loading on gears and pumps, and corrosion. Lubricants must be designed to handle these problems safely and efficiently. Properties of several existing aircraft turbine lubricants are compared with desired lubricant.

**No Harmful Preignition from Lead Deposits.** A. Hundere. *Automotive Industries*, Vol. 103, No. 5, September 1, 1950, pp. 50, 76, 78, 80, 83, illus.

Results of studies in a full-scale single-cylinder engine on the preignition characteristics of combustion-chamber deposits. The effects of operating conditions on the preignition obtained from lead deposits were investigated over a range of r.p.m., fuel-air ratio, intake air temperature, cylinder-head temperature, and spark advance. Benzene, alkylate, and diisobutylene were the fuels used. Lead deposits were incapable of supporting destructive preignition. Metals present in lubricating oil from normal engine wear are of insufficient quantity to cause preignition. However, any fuel or oil containing compounds that melt at about 2,000°F. can cause preignition, and, if the melting point is about 2,500°F., destructive preignition will result. Further studies on spark-plug fouling are needed.

**The Oxidation, Decomposition, Ignition, and Detonation of Fuel Vapors and Gases. XVI—Benzene As a Knocking Fuel in Conditions Promoting the Formation of Finely Divided Carbon.** R. O. King, E. J. Durand, and A. B. Allan. *Canadian Journal of Research*, Vol. 28, No. 8, August, 1950, pp. 308–314, illus. 11 references.

**The Flame Photography of Gunpowder.** Alfred J. Zaehringer. *Rocketscience*, Vol. 4, No. 3, September, 1950, pp. 65, 66, illus.

**Boundary Lubrication of Steel; Blends of Acids, Esters, and Soaps in Mineral Oil.** William Davey. *Industrial and Engineering Chemistry*, Vol. 42, No. 9, September, 1950, pp. 1837–1841, illus. 20 references.

**Extreme Pressure Lubricants; Phosphorous Compounds as Additives.** William Davey. *Industrial and Engineering Chemistry*, Vol. 42, No. 9, September, 1950, pp. 1841–1847, illus. 13 references.

## Gliders (35)

**Collected Researches on the Stability of Kites and Towed Gliders. I—Preliminary Note on the Stability of Kites.** L. W. Bryant and W. S. Brown. **II—Note on High Efficiency Kite Design.** W. S. Brown and L. W. Bryant. **III—The Stability of Kites and Towed Gliders.** W. S. Brown. **IV—The Stability of a Towed Glider.** W. S. Brown. **V—The Lateral Stability of Gliders Towed on Twin Booms or Cables.** W. S. Brown and N. E. Sweeting. **VI—Addendum to Note on the Lateral Stability of Gliders Towed on Twin Booms.** W. S. Brown and N. E. Sweeting. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2303*, 1950 (February, 1942). 35 pp., illus. 7 references. British Information Services, New York. $1.50.

**The Schweizer "I-23."** Paul Schweizer and Ernest Schweizer. *Sailplane and Glider*, Vol. 18, No. 9, September, 1950, pp. 200–202, illus.

## Guided Missiles (1)

**Aerodynamics Research for Guided Missiles.** H. M. Mott-Smith. (Symposium on Ordnance Aeroballistics, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1131*, March 1, 1950, pp. 19–25.

At present the most promising field of aerodynamic investigation for short-range missiles appears to be the development of a series of configurations that would have appropriate stability and control over an extended speed range. Basic and applied research in transonic as well as supersonic speed ranges is needed more than the study of particular missiles and air-frame models.

**Problems of Missiles at Extreme Speeds.** R. Smelt. (Symposium on Ordnance Aeroballistics, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1131*, March 1, 1950, pp. 51–68, illus. 6 references.

Properties of a missile traveling at high supersonic speed may be different from those expected on the basis of perfect-gas aerodynamics. There is difficulty in experimental work since the wind tunnel provides essentially perfect-gas data. Up to Mach 7 such data are probably adequate since the major effect of changes inside the gas molecule itself is not important until temperatures corresponding to stagnation conditions at this Mach Number are reached. Above Mach 7 it appears necessary to supplement hypersonic wind-tunnel work with experimental work at the correct

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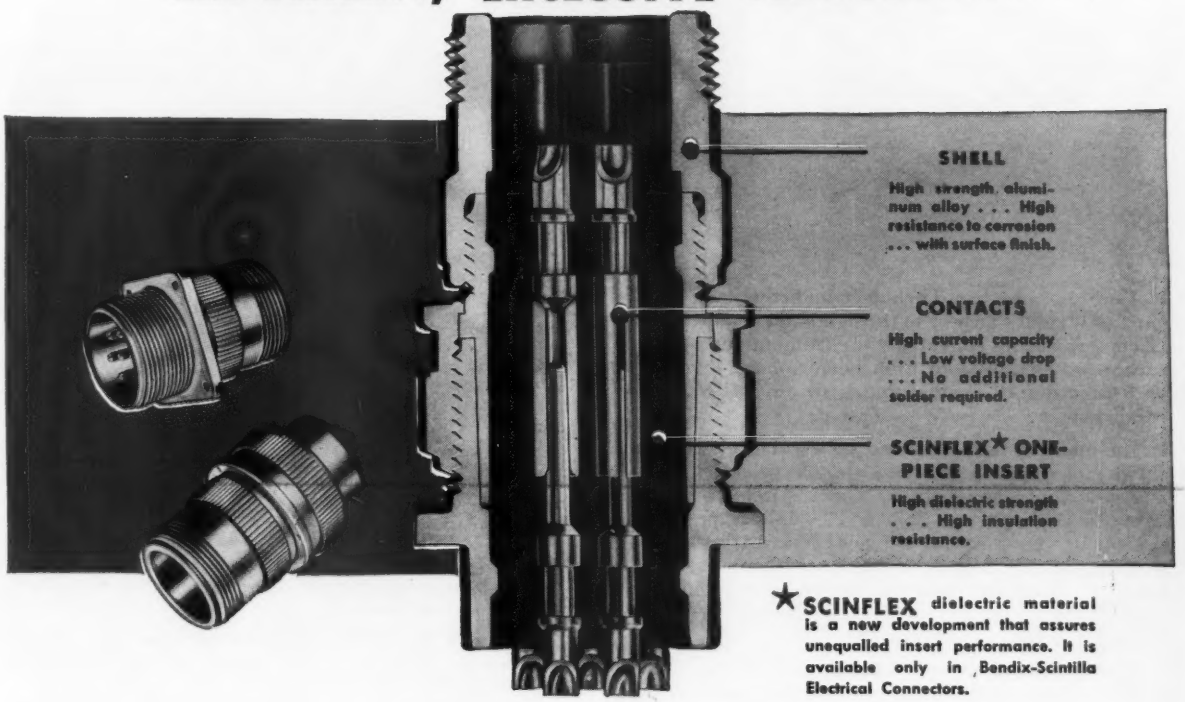
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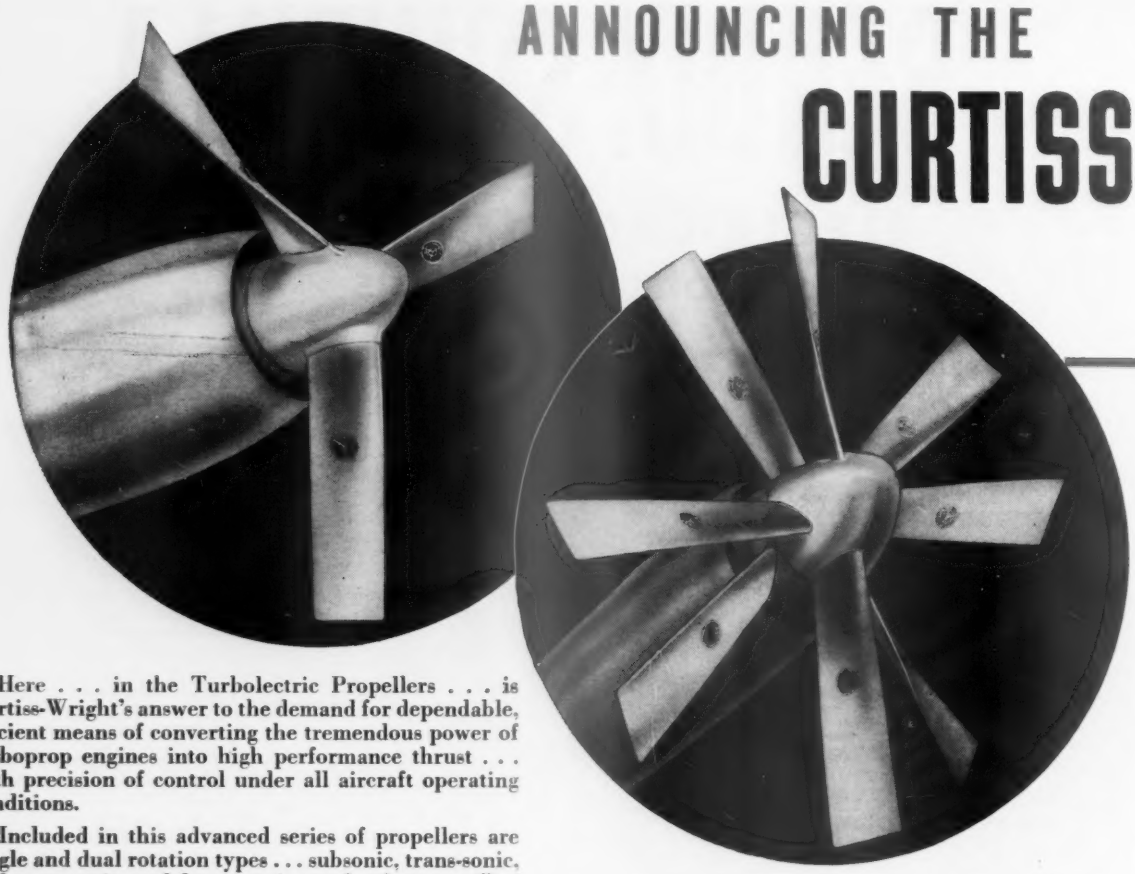

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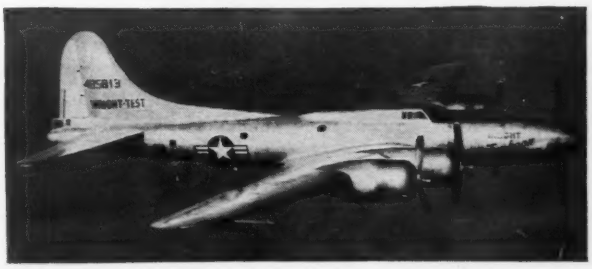
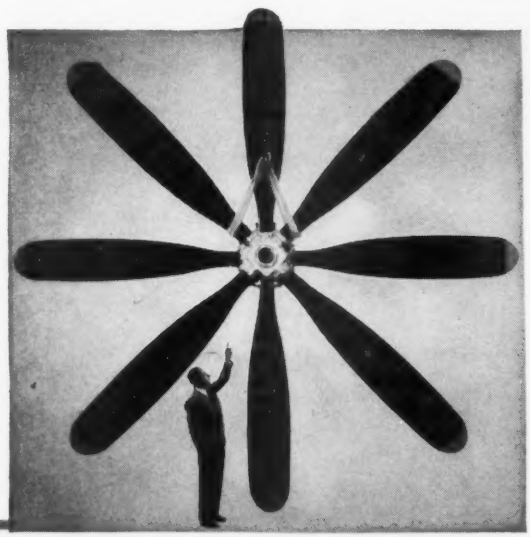


Propelled solely by a predecessor of the Turbolectric Propellers fitted to a high-powered T-35 turboprop in the nose, this special Boeing B-17 "flying test stand" gave a spectacular flight demonstration with the four propellers of its wing engines feathered.



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temperature. Experiments on projectiles in free flights seem to be a practical solution.

**Aerodynamics of Supersonic Aircraft and Missiles.** W. Bollay. (Symposium on Ordnance Aeroballistics, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1131*, March 1, 1950, pp. 27–49, illus.

Supersonic aerodynamics as applied to missiles and aircraft is rather similar to subsonic aerodynamics in its techniques, both theoretical and experimental. The supersonic wind tunnel is the most reliable experimental instrument for the quantitative determination of aerodynamic characteristics, but the tunnel must have good flow characteristics and excellent instrumentation. The construction and operation of the North American Aviation, Inc. 16-in. supersonic wind tunnel is described. For aerodynamic tests, small tunnels with good velocity distributions are likely to be better than large tunnels operating at low-pressure levels. For proof-testing of propulsion systems whose model laws are not known, large propulsion test facilities operating at low pressures may be required.

**Free-Flight Roll of a Simple Arrow Projectile.** A. C. Charters. (Symposium on Ordnance Aeroballistics, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1131*, March 1, 1950, pp. 1–17, illus.

A description of the aerodynamics range of the Ballistics Research Laboratories and the theory of roll motion of arrow projectiles. Results obtained from the firing of arrow projectiles were in sufficient agreement with theory to indicate that the range is a suitable instrument for measuring the aerodynamic properties of the rolling motion of simple arrow projectiles.

**Lift on Inclined Bodies of Revolution in Hypersonic Flow.** G. Grimminger, E. P. Williams, and G. B. W. Young. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, pp. 675–690, illus. 21 references.

**Readers' Forum: Correction for "The Effect of Variation of Mass on the Dynamic Stability of Jet-Propelled Missiles."** M. V. Barton. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, p. 741.

**Theory of Blind Navigation by Dynamical Measurements.** J. J. Gilvarry, S. H. Browne, and I. K. Williams. *Journal of Applied Physics*, Vol. 21, No. 8, August, 1950, pp. 753–761, illus. 12 references.

The differential equation is considered which determines the position of a vehicle from dynamical measurements of the non-gravitational acceleration made internally. Three linear approximations to the gravitational field of the earth, which lead to explicit solutions of this equation, are considered, and their limitations are discussed. An interval-wise solution (linear continuation) for trajectories of extended range is described, which is based on such linear approximations and has definite advantages in this application. The theory is applied to the trajectory of the proposed German A10 vehicle, which was never built and which was to consist essentially of a winged V2 equipped with a booster rocket.

**Investigations of Lateral Stability of a Glide Bomb Using Automatic Control Having No Time Lag.** E. W. Sponder. (*ZWB, Forschungsbericht No. 1819*, May, 1943.) *U.S., N.A.C.A., Technical Memorandum No. 1248*, August, 1950. 54 pp., illus. 12 references.

**Rockets for Studying the Upper Atmosphere.** James A. Van Allen. *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 20, 21, 88–91, illus. Application of high-altitude rockets as new tools for basic atmospheric research and cosmic-ray study.

**Sun Follower for V-2 Rockets.** Harry L. Clark. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 71–73, illus. 5 references.

A photocell-controlled servodrive mechanism keeps a spectrograph mounted in the nose of a spinning V-2 rocket pointed at the sun and permits measurement of radiation intensities down to 500 angstroms. The stabilization system is similar to the tracking unit of the SCR-584 radar, but with a photocell error-signal generator and low-frequency amplifier. This device automatically searches for the sun in the azimuth plane and provides rocket-aspect data for telemetering.

**Lark Production Shows Missile Progress (Fairchild TV-N-9).** David A. Anderton. *Aviation Week*, Vol. 52, No. 21, May 22, 1950, pp. 12, 13, illus.

**The Peenemuende Rocket Center. III.** Krafft A. Ehricke. *Rocketscience*, Vol. 4, No. 3, September, 1950, pp. 57–63, illus. Development and test program of JATO and the A-4 (V-2) missile in Germany.

## Instruments (9)

**A Study of the Legibility of Trans-Illuminated Markings in Aircraft Cockpits. II.** Fred R. Brown. *U.S., Naval Air Material Center, Philadelphia, Naval Air Experimental Station, Report TED No. NAM EL 600*, February 25, 1949. 33 pp., illus. 11 references.

**Visibility of Cockpit Instruments.** Norman Lee Barr. *Journal of Aviation Medicine*, Vol. 21, No. 4, August, 1950, pp. 328–342, 346, illus. 1 reference.

**Levelling by Radar Altimeter.** S. Jowitt. *Engineering Journal*, Vol. 33, No. 8, August, 1950, pp. 689–694, illus.

**New Pressure Cell Cuts Error.** *Aviation Week*, Vol. 53, No. 10, September 4, 1950, pp. 34, 36, illus.

A simplified pressure-measuring system, manufactured by Sierra Electronics Corp., which reduces phase and amplitude errors by the elimination of pressure tubing. The flush-mounted cell, which is screwed into a special flange riveted into the skin of the aircraft or model, gives noise-free operation under conditions of severe vibration or electrical disturbances.

**Maintenance of Pressure Gages.** Robert F. Angell and James Hays. *Instruments*, Vol. 23, No. 8, August, 1950, pp. 853–856, illus.

**Influence of Compressibility on Cylindrical Pitot-Tube Measurements.** L. W. Thrasher and R. C. Binder. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 5, July, 1950, pp. 647–650, illus. 5 references.

**Attenuation of Oscillatory Pressures in Instrument Lines.** A. S. Iberall. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 5, July, 1950, pp. 689–695, illus.

**A Pyrometer for Measuring Total Temperature in Low-Density Gas Streams.** Sidney Allen and J. R. Hamm. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 851–858, illus. 7 references.

Design of a suction pyrometer in which sonic gas velocity is maintained over the thermocouple element at all operating conditions. Errors are reduced to negligible magnitudes or can be evaluated accurately. Reasons for errors in gas-temperature measurements during high-altitude testing of aircraft gas-turbine combustors are reviewed. Tables give calibrated data and service performance of the sonic suction pyrometer.

**The Response of Thermocouples to Rapid Gas-Temperature Changes.** M. W. Carbon, H. J. Kutsch, and G. A. Hawkins. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 5, July, 1950, pp. 655–657, illus. 8 references.

**Sonic-Flow-Orifice Temperature Probe for High-Gas-Temperature Measurements.** Perry L. Blackshear, Jr. *U.S., N.A.C.A., Technical Note No. 2167*, September, 1950. 20 pp., illus. 6 references.

**The Scandia's Engine Failure Detector.** Tore Nilson. *Saab Sonics*, No. 10, April–June, 1950, pp. 8, 9, illus.

Brief discussion, with emphasis on its operational simplicity and reliability, of the Saab KZ2 detector, which is designed to warn of the presence of metal fragments in the engine's lubricating oil.

**Aircraft Ignition Tester.** W. M. Bauer and L. G. Sands. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 87–89, illus., circuit diagr.

Operation of the ignition tester is based on the fact that an aircraft dual ignition system includes two sets of spark plugs. One set of spark plugs is used as an ionization detector to determine if the active set is firing properly. A fairly high voltage is applied across the detector plug; a drop in potential across the plug is sensed by an amplifier and flashes a neon-lamp indicator. If the tester is fitted with a memory switch, the lamp (of a cylinder showing faulty ignition) will remain lighted. A separate electronic circuit is used for each cylinder.

**An Electric Tachometer.** H. G. Jerrard and S. W. Punnett. *Journal of Scientific Instruments*, Vol. 27, No. 9, September, 1950, pp. 244, 245, illus. 5 references.

Speeds of revolution of a shaft can be measured to an accuracy of $\pm 0.05$ per cent, and in any speed range. One periodic motion generated by the rotation of the shaft is combined with a motion from a standard source to give a trace on a cathode-ray tube. The trace appearing on the tube is a Lissajous figure. If the oscillator is set to give a stationary, known Lissajous figure, then the un-

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known frequency can be readily determined, and the speed of revolution can be obtained directly.

**An Accelerometer for Measuring Ship Hull Vibrations.** A. G. Boggis. *Journal of Scientific Instruments*, Vol. 27, No. 8, August, 1950, pp. 212–214, illus.

**A Low-Cost, 16-mm Camera for Rocket Photography.** Roland E. Mueser and Thomas F. Irvine, Jr. *American Rocket Society, Journal*, No. 82, September, 1950, pp. 119–125, illus. Modification of war-surplus GSAP (Gun Sight Aiming Point) cameras to obtain film-transport speeds of over 100 frames per sec. and exposure times of less than one thousandths of a sec.

**A Remote Control Projector for the Examination of Experimental Records on 35 mm. Film.** E. L. R. Webb. *Canadian Journal of Research*, Vol. 28, No. 8, August, 1950, pp. 315–323, illus.

**British Developments in Instrumentation.** John H. Jupe. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 182, 186, 190, 194, 198, 202, 206, 210, illus.

**An Electro-Deposited Surface Roughness Standard.** P. M. Aitchison. *Australian Journal of Applied Science*, Vol. 1, No. 1, March, 1950, pp. 71–74, illus.

The standard consists of a lapped steel block on which are deposited thin strips of chromium of specified width, spacing, and height. This provides a known surface for use in the calibration of stylus-type, surface-finish measuring instruments.

**Electronic Inspection of Engine Cam Contours.** Michael G. Turkish. *Electronics*, Vol. 23, No. 10, October, 1950, pp. 74–77, illus.

With the camshaft mounted in a lathe, the cam pushes a rod-shaped permanent magnet back and forth inside a pickup coil to generate voltage proportional to velocity, which appears as curves of lift, velocity, and acceleration. Circuit diagrams and details of component parts are given. The apparatus can be applied to testing engine-valve motion at high speeds.

**Investigations of Lateral Stability of a Glide Bomb Using Automatic Control Having No Time Lag.** E. W. Sponder. (*ZWB, Forschungsbericht No. 1819*, May, 1943.) *U.S., N.A.C.A., Technical Memorandum No. 1248*, August, 1950. 54 pp., illus. 12 references.

**Modern Servomechanism Testers.** G. A. Korn and T. M. Korn. *Electrical Engineering*, Vol. 69, No. 9, September, 1950, pp. 814–816, illus. 4 references.

**The Optimum Adjustment of Regulators.** P. Hazebroek and B. L. van der Waerden. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 3, April, 1950, pp. 317–332, illus. 4 references.

**Theoretical Considerations on the Optimum Adjustment of Regulators.** P. Hazebroek and B. L. van der Waerden. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 3, April, 1950, pp. 309–315, illus. 1 reference.

**Discussion at the Meeting held on 28th March, 1950 to Inaugurate the Control Section of the Society of Instrument Technology.** *Society of Instrument Technology, Transactions*, Vol. 2, No. 2, June, 1950, pp. 28–33.

**Problems to be Solved in the Development of Control Systems.** A. Tustin. *Society of Instrument Technology, Transactions*, Vol. 2, No. 2, June, 1950, pp. 19–27, illus.

Chief problems in the development of control systems are the need for simplification and lower cost and quicker, simpler, and more positive procedures in the design of apparatus for stated requirements. Mathematical techniques available are varied, but further basic analytic research is needed before design simplification can be achieved. Limitations of present apparatus are shown, and plans for future research are suggested.

**Stabilisation of Closed Loop Control Systems.** A. M. Uttley. *Society of Instrument Technology, Transactions*, Vol. 2, No. 2, June, 1950, pp. 14–18, illus.

Mathematical analysis of the effect of disturbances in closed-loop systems, and the reasons for, and prevention of, continuous oscillations. Successive "echoes" in the system superimpose to form a convergent or divergent series. The test for the convergence of this series is demonstrated for several types of disturbances.

**Servo-Mechanisms: Recent History and Basic Theory.** K. A. Hayes. *Society of Instrument Technology, Transactions*, Vol. 2, No. 2, June, 1950, pp. 2–13, illus.

## Laws & Regulations (44)

**National Status of Aircraft.** John C. Cooper. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 292–316. 63 references.

**The Planned Promotion of Feeder Air Transportation.** Josh Lee. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 347–360.

**Proposed Senate Action on Air Mail Subsidies.** Edwin C. Johnson. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 253–258. 2 references.

**Separation of Air-Mail Pay from Subsidy—Interim Report of Senator Edwin C. Johnson, Chairman of the Committee on Interstate and Foreign Commerce, on May 5, 1950.** *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 333–346, illus.

**Excerpts from Report of U.S. Delegation to the Fourth Session of the ICAO Assembly.** Joan H. Stacy. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 317–327. 4 references.

**Draft Convention on Damage Caused by Aircraft to Third Parties on the Surface As Revised by Legal Commission of Fourth Session ICAO Assembly.** *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 328–332.

**Liability for Crop-Dusting.** Jay L. Olschansky. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 364–370.

**Safety Regulations and Accident Investigation: Jurisdictional Conflicts of C.A.B. and C.A.A. II.** Edward C. Sweeney. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 269–282.

**Use of Aircraft Accident Investigation Information in Actions for Damages.** John W. Simpson. *Journal of Air Law and Commerce*, Vol. 17, No. 3, Summer, 1950, pp. 283–291.

## Machine Elements (14)

**Dynamic Effects of Load Application.** Joseph Brown. *Product Engineering*, Vol. 21, No. 9, September, 1950, pp. 119–121, illus.

Constant acceleration devices that reduce the effect of dynamic loads often cause high peak loads. A method is presented for calculating the actual peak loads and stresses in the cases of momentary load application, constant load application, where the applied force increases in proportion to the time, and the loads resulting from a force applied at a harmonic rate.

**Why Machine Parts Fail. V—Bending and Tensile Fractures.** Charles Lipson. *Machine Design*, Vol. 22, No. 9, September, 1950, pp. 147–150, illus. 2 references.

**Longitudinal and Torsional Impact in a Uniform Bar with a Rigid Body at One End.** A. H. Burr. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 209–217, illus. 19 references.

**The Design of Rubber Mountings.** J. F. Downie Smith. *Iowa State College, Engineering Experiment Station, Engineering Report No. 2*, July 12, 1950, pp. 37–49, illus. 34 references.

### BEARINGS

**How Oil Holes and Grooves Affect Bearing Performance.** *Automotive Industries*, Vol. 103, No. 5, September 1, 1950, pp. 42, 43, 68, 70, 72, illus.

Comparative performance of plain journal bearings with various arrangement of oil holes and grooves in friction tests. The investigation covered five arrangements for feeding oil through the bearing shell and three arrangements for feeding oil from the center of a hollow shaft. Results of the tests are presented in graphical and tabular form. The research was carried on by the National Bureau of Standards under a program sponsored by the N.A.C.A.

**A Mathematical Evaluation of Pressures in a Grease-Lubricated Bearing.** K. B. Lawrence. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 4, May, 1950, pp. 409–413, illus. 12 references.

**A Simple Hydrodynamic Thrust Bearing.** F. R. Archibald. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 4, May, 1950, pp. 393–400, illus. 17 references.

**Turbulence in High-Speed Journal Bearings.** D. F. Wilcox. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 825–834, illus. 6 references.

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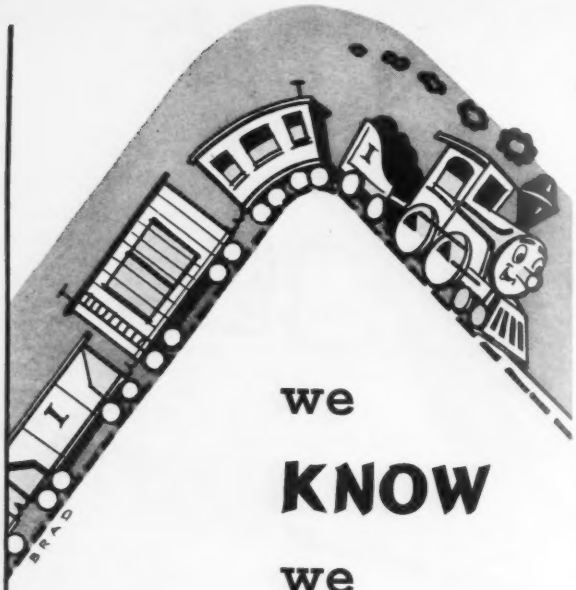


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**The Hydrodynamic Lubrication of Cyclically Loaded Bearings.** E. M. Simons. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 805–812, Discussion, pp. 813–816, illus. 17 references.

**Non-Jamming, Overrunning Ball Bearing Screw and Nut (Eaton Mfg. Co.).** *Automotive Industries*, Vol. 103, No. 6, September 15, 1950, p. 46, illus.

## FASTENINGS

**Gaskets and Bolted Joints.** Irving Roberts. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 169–179, illus. 9 references.

**"Pip" Pins Save Time.** *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 64, 87, 88, illus. The "Pip" quick-release pin, manufactured by Aviation Developments Ltd., for cargo tie-down, seat fixings, bomb-release mechanisms, etc.

## GEARS & CAMS

**Design Factors in Highly Loaded Planetary Gear Trains.** *Product Engineering*, Vol. 21, No. 9, September, 1950, pp. 140–145, illus.

Aircraft propeller reduction gearing is evidence of a new design technique for planetary gearing, which has resulted in a decrease in weight, space savings, and an increase in power rating. Allowances for deflection in service are built into the design. Planet pinions are cantilever mounted instead of straddle mounted. Modification of the gear teeth compensates for operating deflections, which minimizes pitting and breaking. High-contact ratio gears are used to increase the load-carrying capacity. Close manufacturing tolerances and material specifications have been set up. Contact and bending stresses of the gearing are analyzed.

**Spur Gear Durability.** J. E. Rice. *Product Engineering*, Vol. 21, No. 9, September, 1950, pp. 159, 161, illus.

Nomograms for calculating the limiting load for wear of steel gears. The charts are based on the Hertz equation for compressive stress of curved tooth surfaces at the pitch diameter.

**Gears for Extremely High Rotational Speeds.** P. Buttner. (*Technische Rundschau*, No. 11, March 17, 1950, pp. 27–29.) *Engineers' Digest*, Vol. 11, No. 8, August, 1950, pp. 283, 284, illus. Design of a gear unit transmitting 270 hp. at 36,000–42,000 r.p.m.

**Stresses and Deflections of Cylindrical Bodies in Contact with Application to Contact of Gears and of Locomotive Wheels.** H. Poritsky. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 191–201, illus. 8 references.

**Determination of Motor Horsepower from Duty Cycle. II.** L. H. Berkley. *Product Engineering*, Vol. 21, No. 9, September, 1950, pp. 135–139, illus.

## MECHANISMS & LINKAGES

**Locating Axis of Rotation of a Moving Link.** Fred H. Posser. *Machine Design*, Vol. 22, No. 7, July, 1950, pp. 139, 140, 196, illus.

Simple and accurate method of locating an axis about which a rigid member must rotate. Method is applied to the determination of the axis of rotation of retractable aircraft landing gears.

**Acceleration of the Instant Center.** W. J. Carter. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 142–144, illus.

## TRANSMISSIONS, CLUTCHES, & DRIVES

**The Dry Friction Clutch As a Servomechanism Drive.** Franklin S. Malick. *Product Engineering*, Vol. 21, No. 9, September, 1950, pp. 146–149, illus. 4 references.

Consideration of magnetically actuated dry sliding-friction clutches, similar to those commercially available for driving machine tools. A pair of clutches that are arranged to drive a load in either direction, depending upon which clutch is excited, makes a high performance servomechanism. This type of servomechanism is smaller and lighter than any other in the power range (20–500 watts) and is of simple construction. An electromagnet provides a method of obtaining a continuously variable, easily controlled force for clutch actuation. A typical control system for the magnet through the use of two triode vacuum tubes is shown in a circuit diagram. Several types of clutch construction are illustrated, and their limitations are discussed. Weight of typical servomechanisms for 24-volt d.c. operation is tabulated.

## Maintenance (25)

**KLM Design Engine Simulator for DC6 Maintenance.** *Shell Aviation News*, No. 146, August, 1950, pp. 14, 15, illus.

An engine test cart that replaces the operating and control mechanisms of the cockpit and the aircraft's electricity supply to permit each engine to be tested before being mounted in an aircraft.

**Overhaul Center for Jet Engine (Tinker Air Force Base, Oklahoma City).** G. F. Champlin. *American Helicopter*, Vol. 19, No. 9, August, 1950, pp. 6, 7, illus.

**Boeing Service Guide,** No. 35, August, 1950. 8 pp., illus. Model 377 Stratocruiser.

## Management & Finance (45)

**Guide to Government Aviation Buying; Procurement for Air Power; Special Issue.** *Aviation Week*, Vol. 53, No. 13, September 25, 1950, 138 pp., illus. Military aviation spending program; information for suppliers on obtaining bids and contracts from A.M.C. and BuAer; subcontracting procedures; opportunities for electronics sales.

**The Aviation Subcontractor. I—Plans and Estimates for New Work.** William Schweizer. *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 42, 43, illus.

**How to Sell to the Air Force.** Richard E. Stockwell. *Aviation Age*, Vol. 14, No. 3, September, 1950, pp. 17–21, illus.

**What Does the USAF Auditor General Do?** T. R. Rampy. *U.S. Air Services*, Vol. 35, No. 9, September, 1950, pp. 13, 16, 18, 20, illus.

**Engineering Management—Its Job. IV—Direction of Engineering.** Randolphe W. Chaffee. *Machine Design*, Vol. 22, No. 9, September, 1950, pp. 111–118, illus.

## Materials (8)

**Thermoelastic Stress in the Semi-Infinite Solid.** Raymond D. Mindlin and David H. Cheng. *Journal of Applied Physics*, Vol. 21, No. 9, September, 1950, pp. 931–933, illus. 6 references.

Introduction of the solution of the elasticity equations for the center of dilation of a semi-infinite solid into Goodier's theory of thermoelastic stresses reduces the thermoelastic problem to an integration that uses the method of singularities. In the case of a bounded body with a traction-free surface, the stress calculation is merely a problem of differentiation. This solution is applied to a spherical inclusion in the semi-infinite body.

**Nuclei of Strain in the Semi-Infinite Solid.** Raymond D. Mindlin and David H. Cheng. *Journal of Applied Physics*, Vol. 21, No. 9, September, 1950, pp. 926–930. 5 references.

Stress functions for 40 nuclei of strain expressed in terms of the Galerkin vector stress function. The nuclei are derived from the solution of the elasticity equations for the single force in the interior of the semi-infinite solid.

**A Quantitative Comparison of Flow and Deformation Theories of Plasticity.** P. G. Hodge, Jr., and G. N. White. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 180–184, illus. 15 references.

### CERAMICS & CERAMALS

**Bonding Investigation of Titanium Carbide with Various Elements.** Walter J. Engel. *U.S., N.A.C.A., Technical Note No. 2187*, September, 1950. 15 pp., illus. 3 references.

Investigation of the bonding of titanium carbide with fifteen elements, and of the mechanism of bonding. Tests were carried out at minimum fusion temperatures in a helium atmosphere at atmospheric pressure. Cobalt, nickel, chromium, and silicon produced bonds with titanium carbide. Metallographic studies indicate that nickel and cobalt produced extensive interlocking bonds, with nickel having the greater penetration. The silicon-titanium carbide specimens were somewhat fragile.

**Ceramics for Engineering Applications (Materials & Methods Manual No. 62).** John H. Koenig. *Materials & Methods*, Vol. 32, No. 3, September, 1950, pp. 69–84, illus.

### METALS & ALLOYS

**Gas Turbine Alloys 10 Years Later.** Howard Scott. *Westinghouse Electric Corporation, Westinghouse Research Laboratories, Scientific Paper No. 1543*, August 15, 1950. 28 pp., illus. 15 references.

Summary of research done on gas-turbine alloys and future trends for better alloys and production methods. A list of alloys and their compositions and the effect of heat treatment on wrought alloys are presented in tables.

**Heat Shading of Metals Aids Gas Turbine Research.** *Aviation Operations*, Vol. 14, No. 2, August, 1950, p. 26, illus.

**The Influence of Shape of Cross Section on the Flexural Fatigue Strength of Steel.** T. J. Dolan, J. H. McClow, and W. J. Craig. *American Society of Mechanical Engineers*, Vol. 72, No. 5, July, 1950, pp. 469–477, illus. 12 references.

**Investigation of Properties of AISI Type 310B Alloy Sheet at High Temperatures.** E. E. Reynolds, J. W. Freeman, and A. E. White. *U.S., N.A.C.A., Technical Note No. 2162*, August, 1950. 37 pp., illus. 2 references.

Investigation of the loss of ductility and brittleness an A.I.S.I. Type 310B alloy at 1,700°–1,800°F. and 1,900°–2,100°F. and the relative effects of annealing, cold-working, and hot-rolling as initial treatments.

**Impact, Tensile and Hardness Tests on Some Ferrous Alloys and Weld Deposits at Low Temperatures.** T. Fukuroi, G. Monna, N. Ishii, and Y. Okamatsu. (*Tohoku University, Research Institutes, Science Reports, Series A*, Vol. 1, No. 2, pp. 101–105.) *Engineers' Digest*, Vol. 11, No. 9, September, 1950, pp. 315, 316, illus.

Tests at subzero temperatures of specimens of mild steel, low-carbon steel, Cr-Mo steel, and Cr-Mn austenitic steel. Under impact tests, mild steel and Cr-Mo steel proved unsuitable for use at low temperatures. Low-carbon steel plate can be used down to −80°C., but welds of this material are brittle throughout the temperature range of the tests. Under tensile tests, the Cr-Mo steel breaks in a brittle fashion; low-carbon steel remains ductile; the mild steel exhibits a tendency toward brittleness. The austenitic steel proved to be the best material in these tests; it is tough down to the temperature of liquid nitrogen, both in plates and welds. Impact performance of welded structures of low-carbon steel can be improved if a high-alloy Cr-Mn welding rod is used.

**Engineering Steels Under Combined Cyclic and Static Stresses.** H. J. Gough. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 113–125, illus. 17 references.

**Bending of an Ideal Plastic Metal.** J. D. Lubahn and G. Sachs. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 2, February, 1950, pp. 201–208, illus. 7 references.

**Static and Impact Strengths of Riveted and Spot-Welded Beams of Alclad 14S-T6, Alclad 75S-T6, and Various Tempers of Alclad 24S Aluminum Alloy.** H. E. Grieshaber. *U.S., N.A.C.A., Technical Note No. 2157*, August, 1950. 44 pp., illus. 3 references.

**A Study of Methods for Preparing Clad 24S-T3 Aluminum-Alloy Sheet Surfaces for Adhesive Bonding.** H. W. Eickner and W. E. Schowalter. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1813*, May, 1950. 22 pp., illus.

Investigation of the effectiveness of cleaning methods in preparing clad 24S-T3 for bonding with several adhesive processes to determine the need for changing cleaning methods when replacing one bonding process with another. Twenty-two cleaning processes (including solvent treatment, abrasion, alkaline cleaning, acid etching, electrolytic cleaning, and combinations of acid and alkaline cleaning) were applied to the sheets, and four adhesive bonding processes were used. Test specimens of each bonding were loaded to failure in tension at a rate of approximately 600 lbs. per min. Tables compare the cleaning methods and record the failing load and estimated areas (expressed as percentage of total area of the joint) of adhesion failure, cohesion failure, and lack of contact. A second test procedure involved the deposit of contaminants on the metal before cleaning it by some of the more successful cleaning methods previously tried, and the results are similarly listed.

**Note on Sintered Metal with a View to Its Use As a Porous Surface in Distributed Suction Experiments.** H. H. Preston and A. G. Rawcliffe. *Gt. Brit., Aeronautical Research Council, Current Papers No. 9*, 1950 (February 9, 1946). 11 pp., illus. 4 references.

The properties of sintered bronze (Porosint) and results of tests on representative samples of several grades of it available for commercial use. The porosity of beechwood and plaster of Paris was also measured. Porous bronze appears to be the best porous

material so far discovered for use in model construction. It can be welded or soldered to solid parts, but the surface cannot be machined. The finer grades should meet the requirements for distributed suction tests. Pores are fine and closely spaced. The resistance of the finer grades is of the viscous type—i.e., pressure drop varies directly as velocity and inversely as thickness.

**Fracture Modes in High Purity Metals.** T. J. Agnor and M. E. Shank. *Journal of Applied Physics*, Vol. 21, No. 9, September, 1950, pp. 939, 940, illus. 3 references.

Investigation into the properties of zinc showed that transition temperatures exist for high-purity metals other than ferrous materials. The fractured surfaces of the zinc had an appearance corresponding to that of similarly treated ferrous metals, and microscopic examination revealed brittleness and cracks in specimens that had kept their ductile appearance.

**Dependence of the Elastic Strain Coefficient of Copper on the Pre-Treatment.** W. Kuntze. (*Zeitschrift für Metallkunde*, Vol. 20, No. 4, 1928, pp. 145–150.) *U.S., N.A.C.A., Technical Memorandum No. 1287*, August, 1950. 18 pp., illus. 7 references.

**Recent Developments in the Non-Destructive Testing of Materials by Electrical and Magnetic Methods.** W. Jellinghaus. (*Stahl und Eisen*, Vol. 70, No. 13, June 22, 1950, pp. 552–560.) *Engineers' Digest*, Vol. 11, No. 8, August, 1950, pp. 271–275, illus. 15 references.

## NONMETALLIC MATERIALS

**Effect of Defects on the Tensile and Compressive Properties of a Glass-Fabric-Base Plastic Laminate.** Fred Werren and B. G. Heebink. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1814*, June, 1950. 21 pp., illus. 5 references.

Results of 52 compression and 52 tension tests on laminated panels containing defects—high resin content, low resin content, surface wrinkles, butt joints, and lap joints. Lower values of modulus of elasticity in compression resulted from an increase in resin content. Surface wrinkles lowered the tensile and compressive strength of the laminate. Butt joints lower the tensile strength but have only a slight effect on the compressive strength. Reduction of tensile strength in lap joints depends upon the efficiency of the joint; the compressive strength is not appreciably affected. All tests were made on $^1/_8$-in. thick panels of 12 plies of 181-114 glass cloth, parallel laminated with a low-viscosity polyester-type resin, under controlled temperature and humidity conditions.

**Supplement to Directional Properties of Glass-Fabric-Base Plastic Laminate Panels of Sizes That Do Not Buckle.** Fred Werren. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1803-A*, April, 1950. 37 pp., illus. 2 references.

**Effect of Fuel-Immersion on Laminated Plastics.** W. A. Crouse, Margie Carickhoff, and Margaret A. Fisher. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 2, February, 1950, pp. 175–188, illus. 2 references.

**Effect of Circumferential Stiffeners on the Buckling Properties of Thin, Curved Plywood Panels in Axial Compression.** T. B. Heebink and C. B. Norris. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1812*, February, 1950. 24 pp., illus. 8 references.

Analysis of tests on 105 curved-plywood plates stiffened with a single circumferential stiffener and loaded in axial compression resulted in a formula for computing the critical size of the stiffener. If the range of the test data is not materially exceeded, this formula seems to offer a safe basis for design purposes. The critical stress of the stiffened curved panel is that of half of the unstiffened panel if the stiffener has minimum stiffness value equal to that calculated from the formula.

**Contribution to the Problem of Buckling of Orthotropic Plates, with Special Reference to Plywood.** Wilhelm Thielemann. *U.S., N.A.C.A., Technical Memorandum No. 1263*, August, 1950. 122 pp., illus. 8 references. (Translated from the German.)

**Effect of Rapid Loading on the Compressive and Flexural Strength of Wood.** J. A. Liska. *U.S., Forest Products Laboratory, Madison, Wis., Report No. R1767*, June, 1950. 77 pp., illus.

Results of a test program on rapid loading tests in flexure and compression parallel to grain on Sitka spruce, Douglas fir, maple, and birch wood samples at 12 per cent moisture content. Modulus of rupture and ultimate compressive strength increase as time to ultimate load decreases. Rapid loading has only a slight effect on the modulus of elasticity. Unit strength at ultimate load in compression and deflections and deformations to maximum load are fairly constant regardless of loading rate for softwoods but tend to increase as loading time is decreased for hardwoods. Numerical results are tabulated.

**Fundamentals of Adhesion.** G. M. Kline and F. W. Reinhart. *Mechanical Engineering*, Vol. 72, No. 9, September, 1950, pp. 717–772, illus. 69 references.

Fundamental principles for obtaining stronger bonded assemblies and analysis of the chemical bonds in adhesion and of the physical factors closeness of content, surface area, and stress conditions. Test data should be interpreted in terms of the physical and chemical factors involved in adhesive bonds for satisfactory results.

**Rheological Changes During Gel Formation in Adhesive Systems.** H. G. Higgins and K. F. Plomley. *Australian Journal of Applied Science*, Vol. 1, No. 1, March, 1950, pp. 1–20, illus. 29 references.

**Casein Glues: Their Manufacture, Preparation, and Application.** *U.S., Forest Products Laboratory, Madison, Wis., Report No. D280 (Revised)*, May, 1950. 12 pp. 16 references.

## PROTECTIVE COATINGS

**Effectiveness of Molybdenum Disulfide As a Fretting-Corrosion Inhibitor.** Douglas Godfrey and Edmond E. Bisson. *U.S., N.A.C.A., Technical Note No. 2180*, September, 1950. 29 pp., illus. 9 references.

## SANDWICH MATERIALS

**Effect of Shear Strength on Maximum Loads of Sandwich Columns.** K. H. Boller and C. B. Norris. *U.S., Forest Products, Laboratory, Madison, Wis., Report No. 1815*, June, 1950. 22 pp., illus.

Mathematical development of a formula for determining the maximum load on sandwich columns that have small initial irregularities. Experiments correlated with the derivation of the formula showed that columns may fail under transverse shear at loads less than critical. Test material consisted of columns of 0.032-in. clad aluminum facings bonded to a core of $^3/_{16}$- or $^1/_2$-in. cellulose nitrate. The formula demonstrates how maximum loads vary with initial deflections and that small initial deflections can cause failures. Formulas and tests were limited to columns with fixed ends, but it is assumed that the results can be applied to panels. There is good agreement between the calculated and experimental values. The formula can be used for design purposes if a design value for initial lack of flatness is determined. Possibly the method can be extended to cover sandwich panels subjected to edgewise loads. Tests results and calculated values are tabulated.

**Methods for Conducting Mechanical Tests of Sandwich Construction at Normal Temperatures.** *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1556* (Revised), February, 1950. 36 pp., illus.

Procedures for testing sandwich constructions in compression, tension, bending, and shear at normal temperatures and controlled humidity are generally applicable to all types of construction. Preparation of the test specimen, the design and use of the test apparatus, and the loading procedure are given for each type of test. Equations are derived for computing the stress from the test results.

**Supplement to Repair of Aircraft Sandwich Constructions.** A. A. Mohaupt and B. G. Heebink. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1584-A*, May, 1950. 12 pp., illus.

Evaluation of methods to improve the appearance and increase the efficiency of sandwich repairs, using both heat-treatment and room-temperature procedures to set the resins.

# Meteorology (30)

**Operational Feasibility of Aircraft Through Thunderstorms.** L. C. Kappil. *Aeronautical Engineering Review*, Vol. 9, No. 10, October, 1950, pp. 18–27, illus.

**Atmospheric Factors.** *Flight*, Vol. 58, No. 2176, September 7, 1950, pp. 284, 285, illus. Graphs of atmospheric conditions

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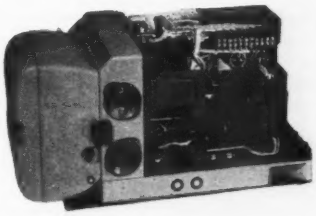

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affecting high-speed and high-altitude flight (density, pressure, and temperature) vs. true air speed.

**Atmospheric Winds.** D. M. Davies. *Royal Aeronautical Society, Journal*, Vol. 54, No. 477, September, 1950, pp. 602–605, illus. 1 reference. Summary of the relations between wind, pressure, and temperature (or their derivatives) as applied to upper-air winds encountered by high-flying, fast aircraft.

**Spectral Dependence of the Attenuation of Brightness Contrast by the Atmosphere.** Howard S. Coleman and Harold E. Rosenberger. *Journal of Meteorology*, Vol. 7, No. 4, August, 1950, pp. 259–262, illus. 6 references.

**Method of Forecasting the Temperature of Fog Formation.** W. E. Saunders. *Meteorological Magazine*, Vol. 79, No. 938, August, 1950, pp. 213–219, illus. 3 references.

**Generalized Criteria for Dynamic Instability.** Warren L. Godson. *Journal of Meteorology*, Vol. 7, No. 4, August, 1950, pp. 268–278, illus. 5 references.

**A Model of Hurricane Formation.** Herbert Riehl. *Journal of Applied Physics*, Vol. 21, No. 9, September, 1950, pp. 917–925, illus. 11 references.

**Some Amendments to "A Meridional Aerological Cross Section in the Southwest Pacific."** F. Loewe and U. Radok. *Journal of Meteorology*, Vol. 7, No. 4, August, 1950, pp. 305, 306, illus. 2 references.

**On the Solutions of the Equations of Motion for Linear Fields.** D. T. Perkins. *Journal of Meteorology*, Vol. 7, No. 4, August, 1950, pp. 291–303, illus. 13 references.

**The Statistical Theory of Turbulence and the Problem of Diffusion in the Atmosphere.** Glenn W. Brier. *Journal of Meteorology*, Vol. 7, No. 4, August, 1950, pp. 283–290, illus. 9 references.

**The Role of Vertical Motions in Ozone-Weather Relationships.** Richard J. Reed. *Journal of Meteorology*, Vol. 7, No. 4, August, 1950, pp. 263–267, illus. 11 references.

**The Motion of Atmospheric Vortices and the General Circulation.** Hsiao-Ian Kuo. *Journal of Meteorology*, Vol. 7, No. 4, August, 1950, pp. 247–258, illus. 12 references.

**Remarks on "Condensation Nuclei and Precipitation."** V. E. Jakl. **Reply.** Horace R. Byers. *Journal of Meteorology*, Vol. 7, No. 4, August, 1950, pp. 304, 305.

## Navigation (29)

**Theory of Blind Navigation by Dynamical Measurements.** J. J. Gilvarry, S. H. Browne, and I. K. Williams. *Journal of Applied Physics*, Vol. 21, No. 8, August, 1950, pp. 753–761, illus. 12 references.

The differential equation is considered which determines the position of a vehicle from dynamical measurements of the non-gravitational acceleration made internally. Three linear approximations to the gravitational field of the earth, which lead to explicit solutions of this equation, are considered, and their limitations are discussed. An interval-wise solution (linear continuation) for trajectories of extended range is described, which is based on such linear approximations and has definite advantages in this application. The theory is applied to the trajectory of the proposed German A10 vehicle, which was never built and which was to consist essentially of a winged V2 equipped with a booster rocket.

**Radar Mapping of the Chicago-New York Airway.** R. C. Borden and E. C. Williams. *U.S., Civil Aeronautics Administration, Technical Development Report No. 66*, April, 1950. 9 pp., illus.

**Shoran—An Electronic Tool for Surveying and Mapping.** J. L. Rannie. *Engineering Journal*, Vol. 33, No. 8, August, 1950, pp. 682–688, illus. 7 references.

## Ordnance & Armament (22)

**Fighter Armament. I—Important Lessons from the Past.** A. R. Weyl. *Flight*, Vol. 58, No. 2174, August 24, 1950, pp. 215–219, illus.

## Personal Flying (42)

**Economics of Executive Aircraft Operation.** N. F. Silsbee. *Aviation Operations*, Vol. 14, No. 2, August, 1950, p. 28, illus.

## Photography (26)

**Shoran—An Electronic Tool for Surveying and Mapping.** J. L. Rannie. *Engineering Journal*, Vol. 33, No. 8, August, 1950, pp. 682–688, illus. 7 references.

**Levelling by Radar Altimeter.** S. Jowitt. *Engineering Journal*, Vol. 33, No. 8, August, 1950, pp. 689–694, illus.

## Power Plants

### JET & TURBINE (5)

**A Contribution to the Design of Radial-Turbomachines.** O. E. Balje. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 15, No. 9, September, 1950, pp. 21–35, illus.

A simplified method for computing the efficiency of radial turbomachines and calculating their characteristics by dimensional analysis. Some general laws of thermodynamics and flow mechanics are applied to the dimensionless coefficients to give the relationship between the efficiency and characteristic values of the turbomachine. Substituting the design requirements into this relationship results in a plot of efficiency vs. design requirements. A further plot shows the correction factor for the efficiency when the speed or impeller diameter differ from the required values. These diagrams give a good estimate of the efficiency of the turbomachine over a wide range of design conditions and design types.

**Calculated Engine Performance and Airplane Range for Variety of Turbine-Propeller Engines.** Tibor F. Nagey and Cecil G. Martin. *U.S., N.A.C.A., Technical Note No. 2155*, August, 1950. 49 pp., illus. 4 references.

**Extrapolation of Static Tests to Predict Operation of Jet Engines in Flight.** C. A. Meyer. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 4, May, 1950, pp. 465–468, illus.

**Investigation of Frequency-Response Characteristics of Engine Speed for a Typical Turbine-Propeller Engine.** Burt L. Taylor, III, and Frank L. Oppenheimer. *U.S., N.A.C.A., Technical Note No. 2184*, September, 1950. 38 pp., illus. 2 references.

**Method for Determining Optimum Division of Power Between Jet and Propeller for Maximum Thrust Power of a Turbine-Propeller Engine.** Arthur M. Trout and Eldon W. Hall. *U.S., N.A.C.A., Technical Note No. 2178*, September, 1950. 40 pp., illus. 2 references.

**Considerations of Thrust Augmentation in Jet Engines; The Different Requirements of Military and Civil Installations.** *de Havilland Gazette*, No. 58, August, 1950, pp. 29, 30.

**The Application of Jet Propulsion to Helicopters.** Wm. Stewart. *Gt. Brit., Aeronautical Research Council, Current Papers No. 8*, 1950. 24 pp., illus. 7 references. British Information Services, New York. $0.40.

The most practical power plants for jet helicopters are ram-jet engines at the rotor tips and the pressure-jet (Doblhoff) system. Each of these systems is compared with the conventional reciprocating-engined helicopter in pay load and range. For a helicopter of a given gross weight, the ram-jet craft will carry a greater pay load, but the range is limited severely by high fuel consumption. The pressure-jet system has a lower fuel consumption but has the added problems of conducting the hot gases to the rotor tips and a high complex compressor unit.

**Direct Method of Design and Stress Analysis of Rotating Disks with Temperature Gradient.** S. S. Manson. *U.S., N.A.C.A., Report No. 952*, 1950. 14 pp., illus. 8 references. U.S. Govt. Printing Office, Washington. $0.15.

**United States Research Project "Squid"; Rocket Ram-Jet and Pulse-Jet.** Hugh Harvey. *Shell Aviation News*, No. 146, August, 1950, pp. 16–18, illus.

**The Solid-Fuel Ramjet.** Edward F. Chandler. *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 19, 86, 87, illus.

Four examples of ram-jet power plants using solid fuel as the propellant, for antibomber missiles and marine torpedoes. The solid-fuel power plants permit greater design simplicity and greater range or load than the liquid-propelled vehicles.

**A Spectrophotometric Determination of Exhaust Gas Temperatures in the Pulse-Jet Engine.** H. F. Quinn. *Canadian Journal of Research, Section A, Physical Sciences*, Vol. 28, No. 4, July, 1950, pp. 411–432, illus. 20 references.

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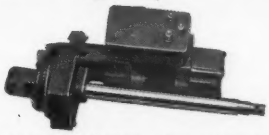

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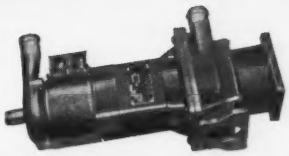

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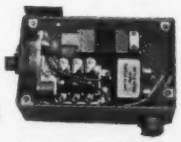

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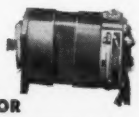

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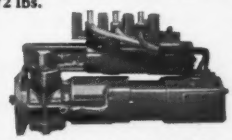

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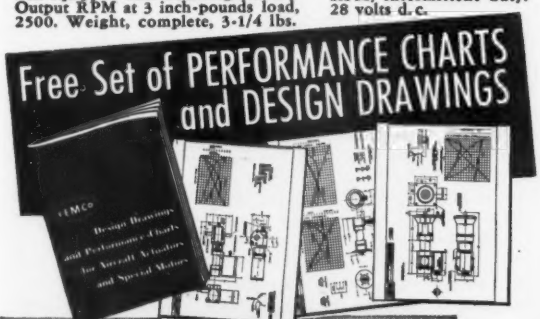
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**Performance Parameters for Air-Turbine-Driven Pumps.** Edmund V. Marshall. *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 66, 68, 84–86, illus.

Development of parameters by dimensional analysis for conveniently plotting the performance of air-turbine-driven pumps. The method is based on the thermodynamic considerations of the turbine and pump rotating on the same shaft. Parameters are applicable to both theoretical and practical studies.

**Analysis of Effect of Variations in Primary Variables on Time Constant and Turbine-Inlet-Temperature Overshoot of Turbojet Engine.** Marcus F. Heidmann. *U.S., N.A.C.A., Technical Note No. 2182*, September, 1950. 41 pp., illus. 4 references.

**The Jet Engine Comes of Age.** R. P. Kroon. *Westinghouse Engineer*, Vol. 10, No. 5, September, 1950, pp. 194–200, illus. History of the evolution of the turbojet engine, indicating performance gains and correlated research in other fields.

**A Perforated-Plate Heat Exchanger.** H. O. McMahon, R. J. Bowen, and G. A. Bleyle. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 5, July, 1950, pp. 623–632, illus. 8 references.

Performance data on heat transfer and flow resistance for the continuous heating of air in experimental variations of a new type of perforated-plate heat exchanger. Effects of hole diameter, plate thickness, and plate separation are indicated. Results are presented as pressure-drop efficiency factor vs. Reynolds Number over a range of 800–4,300.

**Jet Nozzles for Aircraft Gas Turbines.** W. O. Meckley. *Aeronautical Engineering Review*, Vol. 9, No. 10, October, 1950, pp. 33–35, illus.

**Analysis for Control Application of Dynamic Characteristics of Turbojet Engine with Tail-Pipe Burning.** Melvin S. Feder and Richard Hood. *U.S., N.A.C.A., Technical Note No. 2183*, September, 1950. 39 pp., illus. 6 references.

**The (de Havilland) Ghost and Airline Maintenance.** *de Havilland Gazette*, No. 58, August, 1950, pp. 27–29, illus. Engineering costs and maintenance simplicity of the Ghost turbojet engines in the Comet.

**Compounding Is Here to Stay.** Paul H. Wilkinson. *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 36, 37, illus. Power-recovery systems in compound engines; design and performance data on the Wright Turbo-Cyclone 9 and 18 engines.

**P&W Reveals Most Powerful Turboprop (T-34).** Alexander McSurely. *Aviation Week*, Vol. 53, No. 11, September 11, 1950, pp. 12–14, illus.

**Turbo-Cyclone 18 Compound Engine (Wright).** *Shell Aviation News*, No. 146, August, 1950, pp. 19, 20, illus.

**Overhaul Center for Jet Engine (Tinker Air Force Base, Oklahoma City).** G. F. Champlin. *American Helicopter*, Vol. 19, No. 9, August, 1950, pp. 6, 7, illus.

### RECIPROCATING (6)

**Spark-Plug Fouling in Aircraft Engines.** V. E. Yust. *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 54, 55, 105, 106, illus.

Tests conducted at Shell Oil Company's Wood River Research Laboratory to extend spark-plug fouling time under low-temperature lean-mixture operating conditions, using a four-cylinder light aircraft engine. "Fouling time" was the time required for severe engine roughness upon switching from dual to single ignition. Fouled plugs were characterized by a gray-black, glazed deposit of lead oxybromide and metallic lead on the ceramic core. Metallic lead was found to be one of the major causes of fouling. Plug-fouling was obtained under misfire conditions resulting in occasional backfiring. Inserting triple-ply screens in the cylinder intake port reduced backfiring and increased fouling time 400 per cent. The fouling time varied inversely and approximately linearly with the lead content of the fuel. Addition of carbon to the fuel reduced fouling time about one-half. During rich-mixture operation, the formation of carbon reduces the lead oxybromide to metallic lead, which tends to cause misfiring. The time for fouling was best increased by the use of backfire screens in the intake port and by intake-port fuel injection.

**Spark Plug Conference Works Over Ignition Problems.** William D. Perreault. *Aviation Operations*, Vol. 14, No. 9, September 18, 1950, pp. 31–35, 37, 40, illus.

Review of the 6th Annual Spark Plug and Ignition Conference, September 5–7, 1950, Toledo. The 1950 aircraft spark plug data chart prepared by the Champion Spark Plug Co. from data submitted by the air lines is included.

**Combustion Air Control System for Single-Cylinder Testing.** R. C. Fink and D. B. Colyer, Jr. *Instruments*, Vol. 23, No. 9, September, 1950, pp. 904, 905, illus.

**Effect of Size on the Design and Performance of Internal-Combustion Engines.** C. F. Taylor. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 5, July, 1950, pp. 633–645, illus.

### ROCKET (4)

**The Turborocket-Propellant Feed System.** A. G. Thatcher. *American Rocket Society, Journal*, No. 82, September, 1950, pp. 126–138, illus. General turbopump (liquid-propellant feed) systems and flow diagrams; factors involved in turbopump design; operational problems.

**Problems Facing the Rocket Industry Relating to Military Planning.** H. B. Horne, Jr. *American Rocket Society, Journal*, No. 82, September, 1950, pp. 107–118, 125.

## Production (36)

**Determining Practical Forging Cost.** J. J. Sloan and K. R. Denny. *Machine Design*, Vol. 22, No. 9, September, 1950, pp. 151–155, illus. Cost comparisons of forging vs. machining of parts.

**Aluminum Die Forging Design Details That Promote Metal Flow.** A. E. Favre and A. J. Orazem. *Product Engineering*, Vol. 21, No. 9, September, 1950, pp. 130–134, illus.

**The Welding of Thick Aluminum Alloy Plates by the Argon Arc Process.** J. E. Chard and N. Macdonald. *Institute of Welding, Transactions*, Vol. 13, No. 4, August, 1950, pp. 71r–78r, illus.

**The Argonarc Welding of Stainless Steel Sheet.** J. F. Lancaster. *Institute of Welding, Transactions*, Vol. 13, No. 4, August, 1950, pp. 111–121, illus. 10 references.

**Bofors' Forge.** Bertil Liljegren. *Saab Sonics*, No. 10, April–June, 1950, pp. 22–24, illus. The forging department of Bofors Co. (Sweden) and production of light-metal forging of aircraft parts for Saab.

**Some Extracted Notes on Hastalloy Fabrication and Welding.** *Institute of Welding, Transactions*, Vol. 13, No. 4, August, 1950, *Welding Research*, pp. 79r, 80r, illus. 5 references.

**Aluminum Seamless Tubing.** M. F. Cook. *Mechanical Engineering*, Vol. 72, No. 9, September, 1950, pp. 723–726, 732, illus. Production processes.

**Correlation of the Deep-Drawing Qualities of a Material and Its Tensile Test Results.** C. Arbel. (*Revue de Métallurgie*, Vol. 47, No. 5, May, 1950, pp. 388–394.) *Engineers' Digest*, Vol. 11, No. 9, September, 1950, pp. 304–307, illus. 2 references.

**Mathematical Analysis of Springback Angles for Aluminum Sheets.** Y. C. Lee. *Tool Engineer*, Vol. 25, No. 3, September, 1950, pp. 21–23, illus.

**Surface Finish and the Designer.** Roy P. Trowbridge. *Product Engineering*, Vol. 21, No. 9, September, 1950, pp. 122–127, illus. 10 references.

Practical approach by the designer to the specification, measurements, and application of surface-finish control to metallic parts. Comparison of instruments and methods for measuring surface finishes.

**Production Engineering, Administration and Management. V.** J. V. Connolly. *Aircraft Engineering*, Vol. 22, No. 259, September, 1950, pp. 273–277, illus. 18 references. Accounts, dimensional measurement and standardization of parts, quality inspection, time study, and rate fixing.

**Design Economics.** John Van Hammersveld. *Machine Design*, Vol. 22, No. 7, July, 1950, pp. 128–133, illus.

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**Design Economics. II.** John Van Hammersveld. *Tool Engineer*, Vol. 25, No. 2, August, 1950, pp. 36, 37, illus.

**Precision Investment Castings Replace Parts Produced by Other Methods.** Rawson L. Wood and Davidlee V. Ludwig. *Materials & Methods*, Vol. 32, No. 3, September, 1950, pp. 49–53, illus.

**Metal-Stamping Operations and Die Design. I.** S. E. Rusinoff. *Tool Engineer*, Vol. 25, No. 3, September, 1950, pp. 40–42, illus. 1 reference.

## Propellers (11)

**Recent Developments of the Mechanism of the Hydraulic Variable-Pitch Aircraft Propeller.** *Aircraft Engineering*, Vol. 22, No. 259, September, 1950, pp. 264–272, illus.

An outline of the main features of the variable-pitch propeller and the development of the piston-engine hydraulically operated propeller as a brake in the air and on the ground. The gas-turbine engine-and-propeller installation presents a new application for the variable-pitch propeller; each type of installation has its individual problems. Cutaway drawings show the linkage and hub internal structure for the various installations. The contra-rotating propeller is applicable to situations where structural considerations limit diameter propeller to the point where the power absorbed is insufficient.

**A Survey of the Flow at the Plane of the Propeller of a Twin-Engine Airplane.** John C. Roberts and Paul F. Yaggy. *U.S., N.A.C.A., Technical Note No. 2192*, September, 1950. 178 pp., illus. 3 references.

**Propeller Testing.** David H. Frantz, Jr. *Saab Sonics*, No. 10, April–June, 1950, pp. 16–19, illus. Ground and flight testing of the Hamilton Standard Hydromatic 34D51 propellers of the Saab Scandia 90B transport.

**Propellers at Hatfield; A Non-Technical Survey of the Development Factory of de Havilland Propellers Limited.** *de Havilland Gazette*, No. 58, August, 1950, pp. 6–9, illus.

## Research Facilities (50)

**The Arnold Air Engineering Center (Camp Forrest, Tullahoma, Tenn.).** Richard W. Wallace. *Aero Digest*, Vol. 61, No. 3, September, 1950, pp. 58, 59, 103, 104, illus.

**National Research Council's Aeronautical Lab (Ottawa).** *Aircraft and Airport*, Vol. 12, No. 9, September, 1950, pp. 9–11, 13, illus.

**Exposing Aviation Secrets.** Arthur Macdonald. *Canadian Aviation*, Vol. 23, No. 9, September, 1950, pp. 20, 21, 78, illus. Research program of the Canadian National Research Council, Ottawa.

## Rotating Wing Aircraft (34)

**The Application of Jet Propulsion to Helicopters.** Wm. Stewart. *Gt. Brit., Aeronautical Research Council, Current Papers No. 8*, 1950. 24 pp., illus. 7 references. British Information Services, New York. $0.40.

The most practical power plants for jet helicopters are ram-jet engines at the rotor tips and the pressure-jet (Doblhoff) system. Each of these systems is compared with the conventional reciprocating-engined helicopter in pay load and range. For a helicopter of a given gross weight, the ram-jet craft will carry a greater pay load, but the range is limited severely by high fuel consumption. The pressure-jet system has a lower fuel consumption but has the added problems of conducting the hot gases to the rotor tips and a highly complex compressor unit.

**"Look . . . Hands and Feet!"** Jacques Lecarme. *Interavia*, Vol. 5, No. 7, 1950, pp. 375–379, illus. Light-plane and helicopter control systems; piloting problems involved.

**The Seibel (S-4) Helicopter.** Robert N. Elliott, Jr. *Aviation Age*, Vol. 14, No. 3, September, 1950, pp. 28, 29, illus.

**A French Jet-Driven Helicopter (S.O. 1110 Ariel II).** *Esso Air World*, Vol. 3, No. 1, July-August, 1950, p. 28, illus.

**Chicago Heliport.** Frank Coleman. *American Helicopter*, Vol. 19, No. 9, August, 1950, pp. 9, 11, illus.

## Sciences, General (33)

### MATHEMATICS

**On Some General Integration Methods Employed in Connection with Linear Differential Equations.** Gaetano Fichera. *Journal of Mathematics and Physics*, Vol. 29, No. 2, July, 1950, pp. 59–68. 19 references.

**Coefficients for Polar Complex Interpolation.** Herbert E. Salzer. *Journal of Mathematics and Physics*, Vol. 29, No. 2, July, 1950, pp. 96–104. 2 references.

**Solution of Simultaneous Equations Through Use of the A.C. Network Calculator.** L. M. Haupt. *Review of Scientific Instruments*, Vol. 21, No. 8, August, 1950, pp. 683–686, illus. 5 references.

**Arithmetic Operations in a Binary Computer.** Robert F. Shaw. *Review of Scientific Instruments*, Vol. 21, No. 8, August, 1950, pp. 687–693, illus. 1 reference.

**Programme Organization and Initial Orders for the EDSAC.** D. J. Wheeler. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 202, No. 1071, August 22, 1950, pp. 573–589. 3 references.

**A Schmidt Mechanism for Approximate Solution of the Equation of Linear Flow of Heat in a Medium Whose Thermal Properties Depend on the Temperature.** J. C. Jaeger. *Journal of Scientific Instruments*, Vol. 27, No. 8, August, 1950, pp. 226, 227, illus. 3 references.

**Graphical Statistics—An Engineering Approach.** L. R. Hill and P. L. Schmidt. *Westinghouse Engineer*, Vol. 10, Nos. 2, 3, March, May, 1950, pp. 120–123; 157–160; illus.

### MECHANICS

**A Report on the General Assembly of the International Union of Theoretical and Applied Mechanics.** N. J. Hoff. *Aeronautical Engineering Review*, Vol. 9, No. 10, October, 1950, pp. 36, 37.

### MECHANICS—VIBRATION

**Free Periodic Motions of an Undamped Two-Degree-of-Freedom Oscillatory System with Nonlinear Unsymmetrical Elasticity.** Walter W. Soroka. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 185–190, illus. 4 references.

## Space Travel

**Interplanetary Flight.** A. V. Cleaver. *Aircraft*, Vol. 28, No. 10, July, 1950, pp. 12–15, 46, illus. Rocket progress, spaceship design, and human factors involved.

## Structures (7)

**The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed.** C. W. Frick and R. S. Chubb. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, pp. 691–704, illus. 9 references.

**A System for the Excitation of Pure Natural Modes of Complex Structure.** Robert C. Lewis and Donald L. Wrisley. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, pp. 705–722, illus. 7 references.

**Effect of Torsional Stiffness Requirements on Wing Structural Weight.** W. R. Micks. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, pp. 736–740, illus. 3 references.

**Analytical Determination of Coupled Bending-Torsion Vibrations of Cantilever Beams by Means of Station Functions.** Alexander Mendelson and Selwyn Gendler. *U.S., N.A.C.A., Technical Note No. 2185*, September, 1950. 62 pp., illus. 13 references.

**On a Variational Theorem in Elasticity.** Eric Reissner. *Journal of Mathematics and Physics*, Vol. 29, No. 2, July, 1950, pp. 90–95. 3 references.

Formulation of a variational theorem that has both the equations of equilibrium and the stress-displacement relations as appropriate Euler equations. This theorem is applied to the problem of deriving a system of two-dimensional equations for the transverse bending of plates. This derivation had been previously solved by the method of complementary energy. The variational theorem gives the same results as the complementary-energy method, but the process of derivation is somewhat simplified. The flexibility of the variational theorem allows the ap-

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proximations for the stresses and the approximations for the displacements to be used simultaneously.

**Readers' Forum: On the Plastic Buckling of Plates.** P. P. Bijlaard. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, pp. 742, 743. 4 references.

**Experimental Investigation of the Post-Buckling Behaviour of Stiffened, Flat, Rectangular Plates Under Combined Shear and Compression. III.** W. K. G. Floor. *Netherlands, National Luchtvaartlaboratorium, Amsterdam, Report No. S. 367*, April 6, 1950. 27 pp., illus. 5 references. (In English.)

A method for evaluating test results, which is based directly on the characteristic wave-form-ratio slope measurements, and for the determination of the shear load carried by flat plates. Results with the slope measurements were generally much smaller than those obtained by previous methods, although this process is rather cumbersome. The shear load was calculated from the external forces exerted upon the loading construction, including correction for friction in the hinged joints. The equivalent tensile stresses were investigated using Huber's hypothesis, and the calculated stresses were compared with the test values. Permanent deformation could be observed in the plates when the equivalent tensile stress exceeded the yield stress.

**The Buckling Due to Bending of a Simply Supported Rectangular Plate with a Longitudinal Stiffener.** L. H. Mitchell. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. SM. 128*, June, 1949. 27 pp., illus. 4 references.

An approximate solution for the buckling under edge bending, of a simply supported rectangular plate with a longitudinal stiffener. The energy method of solution is used, and only elastic buckling is considered. Stability equations are derived, but, because of the nature of the resultant matrix, the iteration method of solution is too unwieldy. The stability equations are derived for the plate with two longitudinal stiffeners symmetrically placed relative to the neutral axis. When the attempt is made to solve for one infinitely rigid stiffener by the same process, it is concluded that the solution can be obtained more simply if two infinitely rigid stiffeners are considered. Elimination of the stiffener in the tension region of the web has only a slight effect on the critical buckling stress. Solution with two stiffeners gives a good approximation of the case with one stiffener. Placing the stiffener at one quarter of the web depth gives the maximum buckling stress. Problems of this sort appear in the design of plate girder webs from materials of low Young's modulus.

**Thickness and Deflection of Uniformly Loaded Flat Plates (Machine Design Data Sheet).** *Machine Design*, Vol. 22, No. 9, September, 1950, pp. 159–161, illus. 1 reference.

**The Approximate Deflection of Thin Flat Triangular Plates Subjected to Uniform Normal Loading.** F. S. Shaw. *Australia, Aeronautical Research Laboratories, Report No. SM. 150*, May, 1950. 18 pp., illus. 2 references.

A mathematical method in which there is no restriction on the shape of the triangle. It is possible to treat a variety of edge conditions. The analysis can be extended to handle any quadrilateral plate of two nonparallel opposite sides.

**Experimental Investigation of Stiffened Circular Cylinders Subjected to Combined Torsion and Compression.** James P. Peterson. *U.S., N.A.C.A., Technical Note No. 2188*, September, 1950. 16 pp., illus. 6 references.

**Static and Impact Strengths of Riveted and Spot-Welded Beams of Alclad 14S-T6, Alclad 75S-T6, and Various Tempers of Alclad 24S Aluminum Alloy.** H. E. Grieshaber. *U.S., N.A.C.A., Technical Note No. 2157*, August, 1950. 44 pp., illus. 3 references.

**The Stability of the Compression Cover of Box Beams Stiffened by Posts.** Paul Seide and Paul F. Barrett. *U.S., N.A.C.A., Technical Note No. 2153*, August, 1950. 29 pp., illus. 7 references.

**Additional Interpretations of the Solution of the Straight Beam Differential Equation.** S. F. Borg. *Franklin Institute, Journal*, Vol. 250, No. 3, September, 1950, pp. 249–256, illus. 8 references.

Two methods of solution of the Bernoulli-Euler differential equation of the transversely loaded straight beam. The solution is developed for a beam built-in both ends using Green's function; the $V/EI$ and $MD(1/EI)$ diagrams give expressions analogous to the two moment-area relations. Solution by the superposition theorem was obtained by taking appropriate moments of inertia and moments of the $V/EI$ and $MD(1/EI)$ curves.

**Critical Load of Columns of Varying Cross Section.** W. T. Thomson. *Journal of Applied Mechanics*, Vol. 17, No. 2, June, 1950, pp. 132–134, illus.

**Readers' Forum: Plastic Column Behavior.** N. J. Hoff. *Journal of the Aeronautical Sciences*, Vol. 17, No. 11, November, 1950, pp. 743, 744.

**Stress Analysis with Brittle Lacquer.** B. Salmon. (*Technique et Science Aéronautiques*, No. 6, 1949, pp. 343–362.) *Aircraft Engineering*, Vol. 22, No. 259, September, 1950, pp. 256–263, illus.

A method of detection of the weakest part of a component, the measurement of the stress at that point, and the stress distribution over the part. In this French technique, similar to the "Stresscoat" method, the part is coated with a "brittle lacquer," and the finish is baked on under controlled temperature conditions. The test is effected by loading or unloading the coated part in stages. At each stage, the isoentatic line is marked on the part, and the magnitude of the load is noted. The brittle lacquers, which are composed of specially produced resins dissolved in organic solvents, are completely unaffected by humidity. The sensitivity of the coating varies with the nature of the material under test, and the cracks remain visible after the load is removed. Several consecutive quantitative measurements are necessary for acceptable accuracy. The method is suitable also for analysis of moving parts and for the study of residual stresses.

## Thermodynamics (18)

**The Wall-Quenching of Laminar Propane Flames As a Function of Pressure, Temperature, and Air-Fuel Ratio.** Raymond Friedman and W. C. Johnston. *Journal of Applied Physics*, Vol. 21, No. 8, August, 1950, pp. 791–795, illus. 14 references.

The quenching distance between parallel plates has been measured quantitatively for eight pressures ranging from 0.0832 to 2.77 atmospheres and for air-propane ratios of 11–24. Quantitative measurements were made of the effect of surface temperature of the plates and of the inlet gas temperature. A search for catalytic surface effects is described. The minimum quenching distance occurs at an air-propane ratio of 13.5–14.0. Lean mixtures are slightly less sensitive to pressure. When both the inlet gas and the plates are heated, the quenching effect lessens as the temperature increases. Neither the catalytic power of the surface nor its absorptivity for radiation significantly affects the quenching phenomenon.

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**Method for Determining Pressure Drop of Air Flowing Through Constant-Area Passages for Arbitrary Heat-Input Distributions.** Benjamin Pinkel, Robert N. Noyes, and Michael F. Valerino. *U.S., N.A.C.A., Technical Note No. 2186*, September, 1950. 53 pp., illus. 8 references.

**Isentropic Phase Changes in Dissociating Gases and the Method of Sound Dispersion for the Investigation of Homogeneous Gas Reactions with Very High Speed. I–IV, V–VIII.** Gerhard Damköhler. (*Zeitschrift für Elektrochemie*, Vol. 48, Nos. 2, 3, 1942, pp. 62–82, 116–131.) *U.S., N.A.C.A., Technical Memorandums Nos. 1268, 1269*, September, 1950. 58, 41 pp., illus. 16, 13 references.

**Compilation of Thermal Properties of Wind-Tunnel and Jet-Engine Gases at the National Bureau of Standards.** Harold J. Hoge. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 779–783, illus. 4 references.

**Zero-Pressure Thermodynamic Properties of Some Monatomic Gases.** J. A. Goff, Serge Gratch, and S. W. Van Voorhis. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 725–739, illus. 102 references.

**The Thermodynamic Properties of Helium.** S. W. Akin. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 751–757, illus. 11 references.

**Zero-Pressure Thermodynamic Properties of Carbon Monoxide and Nitrogen.** J. A. Goff and Serge Gratch. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 741–749, illus. 35 references.

**Some New Values of the Second Enthalpy Coefficient for Dry Air.** J. R. Andersen. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 759–765, illus. 9 references.

**Pressure Drop and Convective Heat Transfer with Surface Boiling at High Heat Flux; Data for Aniline and n-Butyl Alcohol.** Frank Kreith and Martin Summerfield. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 869–879, illus. 16 references.

**Heat Transfer from an Air Jet to a Plane Plate with Entrainment of Water Vapor from the Environment.** Max Jakob, R. L. Rose, and Maurice Spielman. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 859–867, illus. 12 references.

**New Measurements of the Heat Conductivity of Steam and Nitrogen.** F. G. Keyes and D. J. Sandell, Jr. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 6, August, 1950, pp. 767–775, Discussion, p. 775–778, illus. 9 references.

**A Schmidt Mechanism for Approximate Solution of the Equation of Linear Flow of Heat in a Medium Whose Thermal Properties Depend on the Temperature.** J. C. Jaeger. *Journal of Scientific Instruments*, Vol. 27, No. 8, August, 1950, pp. 226, 227, illus. 3 references.

## Water-Borne Aircraft (21)

**The Penetration of a Fluid Surface by a Wedge.** John D. Pierson. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Paper No. FF-3*, July, 1950. 61 pp., illus. 9 references. Members $1.20; nonmembers, $1.60.

A method for the theoretical determination of the free-surface shape arising from the penetration of the surface of a perfect fluid by an infinite wedge at a constant velocity normal to the surface of the fluid. The conditions for continuity of fluid flow, dynamic stability, and irrotational potential flow are applied to estimated wedge shapes, thus obtaining a unique surface for each given wedge angle. Spray-thickness ratio appeared as the most critical dimension in construction of the free surfaces. Velocity, potential, and pressure distributions along the wedge were calculated by the extension of the solution for the free-surface shape, and an empirical formula was obtained for the total loads on the wetted width of the wedge.

## Wind Tunnels (17)

**Unconventional Wind Tunnel Testing Techniques for the Development of Swept Wing Aircraft.** B. Cohn. *Institute of the Aeronautical Sciences, Annual Summer Meeting, Los Angeles, July 12, 1950, Preprint.* 101 pp., illus. 4 references.

Mountings and installations used in testing two- and three-dimensional models in the Boeing 8- by 12-ft. wind tunnel. Elastically-similar dynamic models of thin sweptback wings are tested under conditions of limited degrees of freedom. The models are constructed with aluminum spars and are covered with a thin surfacing of balsa wood; load may be varied by removing the demountable balsa covering and adjusting weights attached to the spars. Solutions to many complex design problems of high-performance aircraft can be obtained by using set-up configurations designed to provide specific answers to specific problems.

**Recent Developments in High Speed Research in the Aerodynamics Division of the National Physical Laboratory.** J. A. Beavan and D. W. Holder. *Royal Aeronautical Society, Journal*, Vol. 54, No. 477, September, 1950, pp. 545–578, Discussion, pp. 579–586, illus. 63 references.

The high-speed wind tunnels at the N.P.L. are of the induced-flow type. The $9^1/_2$- by $9^1/_2$-in. tunnel operates at a Mach Number of zero to 1.6. Reynolds Number for an airfoil of 2-in. chord is about $0.8 \times 10^6$ at $M = 0.9$. The 20- by 8-in. tunnel was built in 1941 to study the flow around two-dimensional airfoils at Mach Numbers up to that at which choking occurs. The models are usually of 5-in. chord and give a Reynolds Number of about $2 \times 10^6$ at $M = 0.9$. The 9- by 3-in. tunnel is basically a $^1/_4$-scale model of two 36- by 14-in. tunnels to be built by the N.P.L. and can be used for tests up to Mach 1.8. The 18- by 14-in. tunnel was built to provide for detailed investigations of flow past finite wings and wing-body combinations. The pressure at the intake of the working system can be varied from one to three atmospheres. Tests may be made at subsonic speeds up to choking and at supersonic speeds up to $M = 1.6$. Instrumentation of the tunnels is described. Testing procedures include optical work with schlieren cameras. A review of recent experiments at supersonic and subsonic speeds is included. Future projects will be chiefly of a fundamental nature, including experimental checking of the basic compressible-flow theories, boundary-layer tests, and balance and pressure plotting tests on delta wings.

**Investigation of the Turbulence Characteristics of an Experimental Low-Turbulence Wind Tunnel.** H. Schuh and K. G. Winter. (Symposium on Turbulence, July 1, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1136*, July 1, 1950, pp. 49–66, illus. 4 references.

Measurements of the longitudinal intensity of turbulence in the R.A.E. 4- by 3-ft. wind tunnel by hot-wire tests. For these tests, a transformer was inserted in the circuit between the hot-wire bridge and the amplifier, and the wire was held in a rigid mount. Intensity measurements are plotted for fluctuating velocity as a percentage of local velocity vs. local velocity. The turbulence spectrum is presented in curves of the product of frequency and spectrum function vs. the frequency. Noise makes a large contribution to the turbulence in the tunnel. The elimination of nonuniformities in the flow approaching the fan is important in the consideration of fan noise. The damping effect of the screens was investigated and the damping effect on the local velocity is greater than that given by Dryden.

**Studies with an Aerodynamically Instrumented Shock Tube.** A. Hertzberg and A. Kantrowitz. *Journal of Applied Physics*, Vol. 21, No. 9, September, 1950, p. 874–878, illus. 7 references.

Shock tube for studying the limitations of the one-dimensional characteristic theory. Weak pressure waves slightly below sonic speed are photographed simultaneously with the generated shocks to measure the strength of the shock waves and the timing of the exposure. Shock strength is measured by comparing the speed of the reflected wave with the speed of the shock. Photographs of a shock wave along the converging channel of the tube show that the shock assumes a cylindrical shape and is stable. After the shock wave adapts itself to the channel, the one-dimensional method of characteristics should apply to the flow. The experimental position of the shock wave and the position calculated by the method of characteristics are compared.

**50000-HP for a Supersonic Wind Tunnel.** S. L. Lindbeck. *Westinghouse Engineer*, Vol. 10, No. 2, March, 1950, pp. 112–114, illus.

Drive equipment for the N.A.C.A. 6- by 8-ft. closed-circuit-type supersonic tunnel at Moffett Field, Calif.: two 25,000-hp. motors connected in tandem and coupled directly to the axial-flow air compressor. The motors utilize liquid-rheostat speed control.

**Investigation of a Two-Step Nozzle in the Langley 11-Inch Hypersonic Tunnel.** Charles H. McLellan, Thomas W. Williams, and Mitchel H. Bertram. *U.S., N.A.C.A., Technical Note No. 2171*, September, 1950. 71 pp., illus. 5 references.

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# Aeronautical Reviews — BOOKS

## Handbook of Experimental Stress Analysis

**Edited by M. Hetényi. New York, John Wiley and Sons, Inc., 1950. 1,077 pp., diagrs. $15.**

This is a work of considerable scope and technical value. Its broad assemblage of information in the field of experimental stress analysis and elasticity should give it a unique place in the literature of structural engineering, which heretofore only too often has accentuated pure classical theory at the expense of the all-important practical aspects of the strength of materials. In this respect it could be said that the book has filled a real gap in the readily available literature of applied mechanics, besides furnishing a source reference for a number of modern approaches to the stress analysis problem. It goes far beyond the coverage of the usual "handbook" and should not be confused in any way with the "laboratory-manual" variety of materials-testing literature.

Far from being merely an ordinary handbook, as the title might imply, this book actually is an integrated study of the entire subject of experimental stress analysis at a sufficiently high technical level to satisfy the ordinary requirements of the practicing structural engineer, as well as furnishing textbook material suitable for advanced studies and research work. It should be equally useful to both the materials-testing specialist and the designing structural engineer, who must be able to interpret and analyze structural-test data, as well as to set up the necessary experimental programs connected with a project.

The text of this book appears to be well integrated, both in subject matter and in literary style, despite the fact that the different sections of the work have been contributed by approximately 34 collaborating authors, each a recognized specialist in his particular field.

The book is extremely readable, and the subject matter is so well presented that little difficulty should be experienced by anyone with a structural engineering background in following even the more complex theoretical discussions. In the several chapters, which deal to some extent with a.c. and electronic theory, some fundamental knowledge of electrical engineering on the part of the reader is advisable for a good understanding of the details.

In keeping with the "handbook" character of the work, each chapter actually is a separate article on a particular topic, written by one or more of the contributors. These chapters (or articles), numbering eighteen in all, plus the three appendixes, are individually indexed for rapid reference. Likewise, each chapter contains its own extensive bibliography of the pertinent domestic and foreign literature available—an arrangement that should aid considerably any investigator who might wish to obtain additional detailed information on a particular topic. Where necessary, each chapter, although practically self-contained, is cross-referenced to other pertinent portions of the book.

The subject matter of the text includes (by chapters in order) the following topics: mechanical properties of materials, testing machines, mechanical gages and extensometers, optical methods of strain measurement, electrical-resistance gages and circuit theory (including applicable electronic devices and circuits), electric-inductance gages, electric-capacitance gages (from British practice), motion measurements and vibration analysis, strain rosettes, working stresses and the theory of failure with particular reference to elevated temperatures, residual stresses, methods of crack detection, interpretation of service fractures, brittle models and brittle coatings, structural model analysis, mathematical and elastic analogies, photoelasticity, and radiographic analysis (detection of structural flaws and analysis of strains by X- and gamma-radiation). Each of these topics is treated in comprehensive fashion, actually approaching the coverage of a complete textbook in some cases. The text is profusely illustrated with photographs, working drawings, sketches, and electrical circuit diagrams.

In addition to the foregoing chapters of the text, there are three appendixes dealing with the fundamentals of the theory of elasticity, dimensional analysis, and the precision of measurements (application of probability and reduction of observed values).

For a work of such comprehensive scope, it is not possible here to comment adequately or in detail on much of the subject matter. However, this reviewer feels that the book contains much information of potential value to aeronautical structural engineers and structural engineers in other professional fields, regardless of whether or not the engineer actually is engaged in experimental work or structural testing. For example, the article on service fractures alone, with its many photographic illustrations, should be helpful in many cases for assisting the structural engineer or liaison technician in coping with failure problems that may arise. In this respect, however, it does seem rather unfortunate that the authors did not include some helpful material on aircraft rivet failures, instability of thin structural sections and sheet material, etc., since such failure phenomena have so much significance in aeronautical engineering and so much experimental work has been accomplished on these subjects by the aircraft industry. Nevertheless, this presentation of the material on service fractures is so fundamental that it should prove instructive to the average technical reader.

Also of particular interest to the aeronautical engineer are the sections on electric-resistance strain gages, electric-inductance strain gages, electric-capacitance strain gages, vibration pickups and analysis, and strain rosette analysis with the SR-4-type and similar bonded resistance-gage rosettes. These chapters contain both the theory and the practice of such observations, together with sufficient electrical theory and circuit diagrams to meet the requirements of most experimental programs of this type. The chapters on electric-capacitance gages and vibration analysis contain much information for those interested in vibration and flutter analysis and other dynamical problems.

The excellent textbook-sized chapter on photoelasticity covers that subject thoroughly, including a section on three-dimensional problems. The theoretical considerations are treated clearly and carefully, and the numerous photographic illustrations and examples add much to the value of the work. This article should prove interesting to the

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aeronautical stress analyst and structural designer in view of its applicability to structures of unconventional or irregular shapes, and particularly with reference to stress concentration problems in fittings, etc. However, despite the fact that several aircraft components are considered briefly in the text and photographs, the authors appear to make no mention of the effects of shear-web instability on the utility of the method, if such web instability should occur under load in the original prototype structure, as it frequently does in air-frame components.

The chapter covering X- and gamma-radiography will be useful to anyone responsible for the solution of inspection problems involving castings, fittings, etc. It also presents some rather interesting, though specialized, methods of strain analysis by X-ray diffraction.

For the mathematically minded engineer, the article on analogies should prove interesting and stimulating, particularly for the solution of research problems in applied elasticity. Essentially the method of analogy consists of determining a resultant condition in one physical system by solving (often experimentally) for the analogous conditions of another physical system that is governed by mathematical relations identical in form with those of the first system in question. Thus, it is possible to solve for the stresses in a certain structure, for instance, by examining and solving a particular condition in an analogous electrical circuit. The authors show a solution of this sort for a classical shear-lag problem by means of an analogous d.c. electrical network. A number of other structural examples also are given, using analogous systems for solution. This entire chapter is written at a rather high technical level and should be stimulating to those interested in advanced study. It should be possible also to find a number of practical aeronautical structural problems where the methods could be employed usefully.

Altogether, this is an extremely interesting and useful addition to the literature of structural engineering, and it probably will become a standard reference work on the experimental and practical aspects of structural analysis and design.

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## Hydrodynamics; A Study in Logic, Fact and Similitude

**By Garrett Birkhoff. Princeton, N.J., Princeton University Press, 1950. 199 pp., illus., diagrs. $3.50.**

This is a thought-provoking combination of review, survey, and original contribution in theoretical hydrodynamics. It is concerned primarily with a critical examination of the purpose, methods, and results of theoretical analysis in explaining experimental facts. In it, the author expresses a hope and gives a promise that a more ordered foundation of theoretical fluid mechanics can be found. It is not a textbook; rather, it is a suggestion to the creators of hydrodynamic theory and authors of future texts that their subject has considerable order that has not been expressed in previous texts nor fully exploited to advance the subject.

About half of the book, the first two and a half chapters, is devoted to showing, largely by example, the complex relationship between theory and fact in hydrodynamics. In Chapter I, a large number of hydrodynamic paradoxes are discussed to illustrate the pitfalls appearing in the application of physical principles that have sometimes proved useful, but which, nevertheless, are not universally true. The paradoxes are categorized into asymptotic paradoxes that result from neglect in differential equations of terms whose coefficients are small; into symmetry paradoxes where the assumption is made that almost symmetrical causes produce almost symmetrical results; and into topological paradoxes in which there are gross errors in the assumed shape of streamlines, for example, in flows with wake. Among the examples are many familiar ones and some much less so. Included are D'Alembert's, Earnshaw's, Eiffel's, and Stokes' paradoxes, as well as the triple shock, the Magnus effect, and the rising bubble paradoxes.

The author uses "paradox" to refer to plausible arguments yielding conclusions at variance with physical observation. Such a definition seems to lead

to an ever-increasing number of paradoxes since there must always be limitations on the applicability of a particular theory. Moreover, every theoretician starts with assumptions that are plausible to him; hence, every incorrect theory yields a paradox. There may be considerable question whether some phenomena described as paradoxes are not just bad approximations. This may be part of the author's point in Chapter I, where he urges mathematicians to investigate carefully the limits of application of all their deductive reasoning.

There is more cohesion in Chapter II, which recounts the recent progress in free boundary theory. This is a field in which the author has made contributions, and this treatment is clearly and interestingly written. It reiterates the thesis that theory—in this case applied to flows whose boundaries must be determined by a knowledge of the pressure along them—must be continually realigned with experimental fact, and, when it is, it produces varied and useful results.

Modeling and dimensional analysis are treated in Chapter III. As he develops the theory, the author points out that dimensional analysis is a limited application of group theory and discusses the much broader and more powerful applications of group theory in the solution of hydrodynamic problems. Several well-known modeling analyses are given as examples, including inertia, Reynolds, Froude, cavitation, and Mach models. In these examples, the value of the group concept is shown in testing the validity of mathematical theories and reducing the number of necessary parameters.

In Chapter IV, the utility of group theory for integrating the differential equations of fluid mechanics is developed. By application of the methods of search for symmetric solutions and separation of variables, the differential equations of a number of interesting fluid-mechanics problems are solved, including the Prandtl-Meyer expansions, Taylor-Maccoll conical flows, nonstationary one-dimensional compressible flows, spiral viscous flows, and laminar boundary layer. In including these many examples, the author states that he is not trying to collect all of the problems known to be solvable by these methods but rather that he is illustrating the wide variety of problems that can be treated by the methods. Again the author expresses his hope that the debt owed to group theory by fluid mechanics will be recognized.

In the final chapter, entitled "Virtual Mass and Groups," the group concept is applied to the force equations for a rigid body moving in a perfect fluid.

In summary, I believe that Professor Birkhoff's book will prove to be interesting to advanced workers in the theoretical hydrodynamics field. At times, the numerous examples cause the reader to lose sight of the principal points of the argument, but even so it is interesting to find a collection of solutions so clearly related. I think everyone will join Professor Birkhoff in his often expressed hope that a more thorough application will produce more general results in hydrodynamics. Also, I am sure everyone will agree with him that the results of theory as applied to hydrodynamics often diverge from experimental results unless there is a continual alignment of the theories with the facts.

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## German Aviation Medicine, World War II

**Prepared Under the Auspices of the Surgeon General, U.S. Air Force. Washington, U.S. Govt. Printing Office, 1950. 2 Vols. 1,302 pp., illus. $8.50 per Set.**

At the close of the European phase of World War II it became evident that first-hand information on aviation medicine would become available. Consequently, a team of experts from the United States Air Forces visited centers in Germany collecting data and, with a group of German aeromedical scientists, began the assimilation of all available material at an established center in Heidelberg. After all material had been collected, the problem of translation and preparation for publication was transferred to the School of Aviation Medicine, Randolph Field, Tex.

One of the first questions to arise was whether German aviation medicine had progressed further than that of the United States by the end of the war. Review of the two volumes does not give a clear-cut answer to this question. In some fields the German scientists made greater advances and, in others, less than we. For example, the United States pioneered in superior oxygen equipment, including pressure-breathing apparatus, which the Germans did not have. They, as a result of accelerated production of high-speed jet fighters for defense, developed an ejection seat, which we did not have.

The problem of aero-embolism appeared first in German literature in 1941, although all important details of this syndrome were contained in Armstrong's *Aviation Medicine* in 1939. Furthermore, the Germans made no attempt to design body armor until American body armor was captured in 1943.

In Germany before the war, aviation medicine was restricted in aeronautical research mainly as an exact science resting primarily in the hands of physiologists and pathologists. With the advent of war the collaboration of almost all branches of medicine was necessary. This was evidenced by the fact that during the war all problems related to aviation medicine were placed under the German Air Surgeon.

In reading the various chapters of these two volumes, one notes that some are of historical value, some deal with present-day problems, and others are concerned with problems of the future.

Part I of the first volume is concerned with the development and organization of aviation medicine in Germany. This includes a history of aviation medicine and the development of various fields of research. Included in the field of research are such subjects as high altitudes, acceleration, temperature and climate, and the physiology of the reflexes and senses.

The second part is concerned with aerodynamics and aviation. One chapter notes that characteristics of various aircraft are the important factors acting on man and correlates the engineering aspects of flying with physiological problems. In addition, the V-1 and gliders are discussed.

A considerable portion of the first volume discusses the physical fundamentals, methods of investigation, and physiological fundamentals of high altitudes. In this section, the problems and observations of the stratosphere are discussed. Considerable research and study are made on respiration during acute and chronic hypoxia. These include the general aspect, definition of terms, and the effect of hyperventilation. Following the chapter on electrocardiograph and oxygen deficiency, altitude tolerance, and decompression sickness, the volume continues with reports on work done on German altitude oxygen equipment, pressure suits, and cabins.

The final section in Volume I is entitled "Acceleration." An introduction to devices for measuring is followed by chapters on brief acceleration, prolonged acceleration, parachute shock, and protective measures.

The first portion of Volume II continues with problems of vibration, heat, and cold.

The last portion of the second volume will be of more interest to the flight surgeon than to the research physiologist. This part is concerned with the examination of the flier, which includes selection, care and training, and information on nutritional problems. The following section gives a record of air evacuation and German air-sea rescue service. The closing chapter discusses blast effects as to physical principles, pathology, and blast injuries.

It was interesting to find that application for flying training was voluntary up to the end of the war. Also worthy of note was the fact that examination of applicant flying personnel closely paralleled that of the United States. In addition to a complete physical examination, the Germans also used a system of psychological examinations for selection of fliers.

The German aeromedical men began altitude indoctrination following a large number of cases of hypoxia in 1940. In medical care of fliers, the Germans maintained medical observation centers and convalescent hospitals for their care. The German flight surgeons also were active in air evacuation. At the end of the war nearly three million patients had been evacuated. This was possible only by the help of troop carrier units since the evacuation units never were sufficient to handle this huge group. The closing chapter on blast injuries is important and interesting.

The information in these two volumes in many instances supplements the aeromedical knowledge of the United States and should contribute to the general progress of aviation medicine.

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### Air Transportation—Traffic and Management

**By Thomas Wolfe. New York, McGraw-Hill Book Company, Inc., 1950. 725 pp., diagrs., maps. $6.00.**

The name of Thomas Wolfe is well known in aviation, not only because he has long been associated with various companies in air transport and allied fields, but also because of his written papers and his talks. Tom Wolfe has always added to the knowledge of air transportation by detailing experiences and practices found in the field of aviation or by advancing new theories.

His 725-page book, *Air Transportation—Traffic and Management*, is a classic in the literature on the subject in both of these respects. As such, it is inevitable that it will become a standard reference and a standard textbook in the field of air transportation.

In preparing the book, Mr. Wolfe consulted many people and read many publications. In his acknowledgments, he lists the names of 160 people who were helpful personally or through their publications in establishing the basic material of the book. By the use of such extensive references, Mr. Wolfe has been able to gain a proper balance of theories and practices that give a most complete view of air-transport industry thinking in addition to his own point of view.

The book starts out with a review of the history of air transportation and its present status both in the United States and abroad. It then goes into the military air transport services of the United States, covering their routes, equipment, and operation details. This introductory material occupies approximately 150 pages. It then goes extensively into the present position of the Government with respect to air transportation, reviewing Government regulation and development with particular emphasis on the C.A.A. and C.A.B. organizations. It also reviews some of the thinking and theory behind the establishment of the Government in its present place of importance with respect to U.S. air transportation.

In getting into the inner workings of air lines, to which Mr. Wolfe devotes the greater part of his book, the subject of air-line organization and air-line revenue and costs are the first subjects taken up. This positioning is rather significant because, unlike so many books on the subject, *Air Transportation—Traffic and Management* emphasizes the business approach to air transportation rather than the more glamorous operations approach. As air transportation becomes a more stable industry, it is only natural that the successes and failures will be based upon proper business management, and the significance of this book will be correspondingly increased for the future.

Mr. Wolfe goes into various procedures, policies, and theories in traffic sources and forecasting, air-line tickets and ticket offices, reservation systems, and general tariff structures. He also goes into details of the policies of air-line sales, passenger service, air mail, air express and air freight, publicity and advertising, and public education.

All in all, the book is not intended as a book for technical aid in an air line's operation or engineering department. It does give a good business approach to the traffic, sales, and passenger service aspects of air transportation, and those in the technical field of aviation will find it valuable for education on the sales and service side of air transportation. It will be valuable also for the student entering air transportation, whether he plans to go into the technical, business, or sales field.

The book is a must among present-day publications on air transportation. It surely can be said that any well-stocked aviation library will have at least one copy of *Air Transportation—Traffic and Management* on a well-used shelf.

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## Mechanics of Deformable Bodies

**By Arnold Sommerfeld. Translated from the 2nd German Edition, 1947, by Gustav Kuerti. New York, Academic Press, Inc., 1950. 396 pp., illus. $6.50.**

The University and the Polytechnic Institute of Munich are world-renowned for their high academic standard, and many outstanding engineers and scientists are alumni of these institutions. Munich was particularly famous for its Physical, Mathematical, and Mechanical Engineering Division. Professor Sommerfeld and the late Professor Föppl are largely responsible for that well-deserved fame.

Professor Sommerfeld's life has been filled with researches and achievements in numerous branches of theoretical physics such as electrodynamics, optics, statistical mechanics, theory of relativity, and theory of quanta. His books and many papers are considered classics of the scientific and theoretical literature.

In the last few years Professor Sommerfeld (84 years old at this writing), who is not only one of the world's most famous physicists but also a pedagogue of great ability, has published a set of six textbooks. They are: *Mechanics, Mechanics of Deformable Media, Electrodynamics, Optics, Statistical Mechanics,* and *Partial Differential Equations in Physics.* The last volume was translated into English about a year ago, and the present volume, which is just off the press, will undoubtedly be followed by the translation of the other four treatises.

The aim of Professor Sommerfeld is "to give the reader a vivid picture of the vast and varied material that comes within the scope of theory when a reasonably elevated vantage point is chosen." This is not a book for the undergraduate. Even the mature engineer may find some difficulty in following certain chapters because, to appreciate this work, one has to be well versed in advanced mathematics; both tensor and vector analysis are prerequisites.

Eight chapters comprise this work. Chapter I starts with the "Fundamentals of Kinematics of the Deformable Bodies," in which the reader finds a review of vector analysis and is also introduced to the tensor notation. Chapter II deals with the "Statics of Deformable Bodies." An excellent explanation of the stress-strain relation and an introduction of the concept of elastic potential are included. To the aeronautical engineer, Chapter III is of great interest. It deals with "Dynamics of Deformable Bodies," and viscous fluids are discussed. Chapter IV explains the "Vortex Theory" and should be read in conjunction with Chapter V, where the "Theory of Waves" is discussed and is given a thorough explanation. Chapter VI, "Flow with Given Boundaries," is extremely timely since it treats a number of problems encountered in jet propulsion. Chapter VII, "Supplementary Notes on Selected Hydrodynamic Problems," deals with the hydrodynamic theory of lubrication and is treated masterfully. Chapter VIII is "A General Theory of Elasticity." Of particular interest is the section on crystal elasticity where the author touches on classical crystallography and makes the understanding of the subject so much easier because of the introduction of precise mathematical concepts permitting the solution of such problems. There are four appendixes dealing mostly with tensor analysis and tensor notation.

The translation by Mr. G. Kuerti of Harvard University does justice to the original text. Anyone who knows how involved and complicated the German language is will join this reviewer in congratulating the translator because, in no instance, can the influence of the original language be detected in this volume.

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# Book Notes

### AIRPLANE DESIGN

**Modern Aircraft Design.** J. L. Nayler. London, Temple Press, Ltd., 1950. 122 pp., illus., diagrs. 8*s*. 6*d*.

In this book, intended for technicians in industries allied to aeronautics, the background of aerodynamic and structural knowledge behind the design of an aircraft is described. There is an interesting historical introduction comparing early and recent airplanes and a second chapter on the various steps through which a design progresses. Discussions of landing gears, deicing equipment, cabin pressurization, noise, and other related problems are included, and various typical aircraft are described. The quest for extremely high and extremely low speed is covered in the final chapter. The author is Secretary of the Aeronautical Research Council of Great Britain.

### ELECTRONICS

**Antennas.** John D. Kraus. New York, McGraw-Hill Book Company, Inc., 1950. 533 pp., diagrs. $8.00.

In this textbook for upper class and graduate engineering students, a unified treatment of antenna from the electromagnetic theory point of view is presented, with emphasis on engineering applications. The fundamental theory of point sources and of the antenna as an aperture is discussed in the first four chapters, which are followed by chapters on linear, loop, and helical antennas, theories of biconical and helical antennas, self- and mutual impedance of antennas, and the theory of arrays of linear antennas. Reflector-type, slot, horn, complementary, lens, long-wire, and other types of antennas are then taken up, and the final chapter deals with antenna measurements and wave polarization. The author is Professor of Electrical Engineering at the Ohio State University.

**Radio Control for Models.** G. Honnest-Redlich. Billington Road, Stanbridge, Beds., Aeromodeller (Harborough Publications), 1950. 129 pp., illus., diagrs. 8*s*. 6*d*.

This book, written for the airplane and boat model maker, covers fundamental theory, power supply, circuits, relays, servo and other controls, and the installation and operation of apparatus for the radio control of models. Emphasis throughout is placed upon practical step-by-step procedures, with a minimum of theory, and considerable attention is given to the electromechanical aspects of the problem. There is a separate chapter on ultra-high-frequency transmission.

**Primary Batteries.** George Wood Vinal. New York, John Wiley & Sons, Inc., 1950. 336 pp., illus., diagrs. $5.00.

New developments in the dry-cell battery field through the use of the electron microscope and the X-ray and mass spectrographs have made possible the production of batteries to meet the requirements of changed military and meteorological requirements. Higher discharge rates and the capability of operating at temperature extremes are characteristic of the quality advances made in recent years. The first five chapters dea with history, materials and production, operating characteristics, and the effect of low temperatures on dry cells. Next is a comprehensive chapter on standard dry cells and standards of electromotive force. The final six chapters deal with air-depolarized batteries, including a discussion of chlorine depolarization, copper and copper oxide cells silver chloride and chloride batteries, lead cells, having soluble reaction products, mercury oxide and vanadium dry cells, and fused-electrolyte cells A considerable amount of previously scattered material is gathered conveniently in this book, filling a definite need. Dr. Vinal is associated with the National Bureau of Standards.

### GENERAL WORKS

**Mid-Century; the Social Implications of Scientific Progress.** (Massachusetts Institute of Technology, Mid-Century Convocation, March 31, April 1, 2, 1949.) Edited and Annotated by John Ely Burchard. Cambridge, The Technology Press; New York, John Wiley & Sons, Inc., 1950. 549 pp. $7.50.

This volume contains the texts of 37 addresses at this convocation by Winston Churchill, Karl T. Compton, Vannevar Bush, and others of various nations. The discussions from the floor and collateral documentation from other speakers and writers and from newspaper reports and editorials have been included, and numerous footnotes have been added to correlate the ideas of the speakers. The range of topics extends from broad views to discussions of specialization in education, cooperative research, and instances of economic planning.

### MACHINE ELEMENTS

**Mechanical Wear,** Being the Proceedings of a Summer Conference on This Subject Held in June 1948 at the Massachusetts Institute of Technology. Edited by John T. Burwell, Jr. Cleveland, American Society for Metals, 1950. 387 pp., figs. $6.50.

Contents: Dimensional Considerations in Friction and Wear, C. Fayette Taylor. Wear in Diesel Engines, C. G. A. Rosen. Wear of Automotive Engines—Cylinders and Rings, Paul S. Lane. Fuel and Lubrication Factors in Piston Ring and Cylinder Wear, A. G. Cattaneo and E. S. Starkman. Chemical Aspects of Wear and Friction, R. G. Larsen and G. L. Perry. The Vapor-Lubrication of Graphite in Relation to Carbon Brush Wear, Robert H. Savage. The Wear and Damage of Metal Surfaces with Fluid Lubrication, No Lubrication, and Boundary Lubrication, F. P. Bowden and D. Tabor. Wear in Steam Turbines, Norman L. Mochel. The Need for Studies of "Real" Hydrodynamic Lubrication, R. W. Dayton. The Dielectric Strength of Oil Film in Plain Bearings, C. M. Allen. Gear Wear As Related to the Viscosity of the Gear Oil, H. Blok. Surface Deterioration of Gear Teeth, J. O. Almen. Recent Roll Tests on Endurance Limits of Materials, E. Buckingham and G. J. Talbourdet. Hardness and Its Influence

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## MATERIALS

**Treatise on Powder Metallurgy. Vol. II, Applied and Physical Powder Metallurgy.** Claus G. Goetzel. New York, Interscience Publishers, Inc., 1950. 910 pp., illus., diagrs. $18.

The present volume incorporates the advances made in Germany during World War II in the technology of powder metallurgy, including methods of manufacturing iron powder and powder production in the hard-metal field. The first ten chapters are concerned with applications of powder metallurgy to refractory metals and alloys, hard metals, electrical and magnetic materials and products, ferrous and nonferrous materials for structural parts, porous products, friction products, dental alloys, and miscellaneous applications for metal powders. The theoretical part opens with a comparison of physical properties of sintered and fused industrial metals and alloys and proceeds into a survey of sintered metals and alloys for potential industrial use. Two chapters follow on stress analysis of sintered metal structures and an appraisal of testing methods. There is an extensive review of the numerous theories of bonding and sintering, including a discussion of atomic migration during sintering. The final chapter deals with the future of powder metallurgy. Numerous references to the literature are included, and author and subject indexes are provided.

**The Mechanical Properties of Wood.** Frederick F. Wangaard. New York, John Wiley & Sons, Inc., 1950. 377 pp., illus., diagrs. $6.00.

Though it is based on the book of the same title published in 1931, by Dean George A. Garratt, much of the material in this book is entirely new. About 250 references are given in bibliographies at the ends of sections, and an additional 250 more specific references are given in footnotes. The four sections deal with the Basic Mechanical Properties of Clear Wood, Factors Affecting the Mechanical Properties of Wood, Working Stresses for Structural Lumber, and Timber Testing. The author is Associate Professor of Forest Products at Yale University.

**McGraw-Hill Directory of Chemicals and Producers.** New York, McGraw-Hill Publishing Company, Inc., 1950. 558 pp. $20.

This first 1951 edition of this directory lists alphabetically over 12,000 chemical raw materials, industrial and fine chemicals, dyestuffs, and prominent semifinished products such as synthetic resins and metal powders. The location of shipping points of each supplier is indicated, and the appropriate shipping labels are indicated for explosives and other dangerous materials. The various grades of each product are listed separately. Cross references from synonyms and trade names are liberally included. Over 300 suppliers, some having more than 50 plants, are included in a separate alphabetical list.

## MILITARY AVIATION

**The Price of Survival.** Joseph B. Sweet. Harrisburg, Pa., Military Service Publishing Company, 1950. 230 pp. $2.85.

An evaluation and a comparison are presented of military and industrial capacities of all countries, with particular emphasis on Russia, the United States, and the North Atlantic Treaty Organization. The objectives as seen today of the democracies and of the Soviet Union are reviewed, and the probable progress of a global war is outlined. It is recommended that national security for the western nations be based upon specialization for each nation according to its military capabilities, following a plan of American foreign assistance devoted to mutual defense rather than the mutual economy. General Sweet's analysis is authoritative and brings together a considerable amount of factual data.

**The Effects of Atomic Weapons.** Prepared for and in Cooperation with the U.S. Department of Defense and the U.S. Atomic Energy Commission Under the Direction of the Los Alamos Scientific Laboratory. New York, McGraw-Hill Book Company, Inc., 1950. 456 pp., illus., diagrs. $3.00. (Also available from U.S. Govt. Printing Office, Washington, Paper Cover, $1.25.)

In this authoritative technical summary, the effects of the complex atomic explosive phenomena are presented quantitatively, beginning with two chapters on nuclear fission principles and a description of an atomic explosion. Underground and underwater explosions as well as air bursts are considered, and shock, physical damage, thermal radiation, and nuclear radiation are treated in detail. The final chapters deal with decontamination, effects on personnel, and protection of personnel. The book supplies the essential scientific and technical information required in planning for the new and unusual situations that could arise from the explosion of an atomic bomb.

## PRODUCTION

**Fundamentals in the Production and Design of Castings.** Clarence T. Marek. New York, John Wiley & Sons, Inc., 1950. 383 pp., illus., diagrs. $4.00.

In this textbook for engineering students, processes and equipment are discussed in detail in the first six chapters, followed by a chapter on production planning. Four chapters on the properties and behavior of ferrous and nonferrous cast metals follow, and the book concludes with chapters on cleaning and inspection and on design for economical molding and to eliminate defects. A bibliography of 39 books is included. The author is Associate Professor of Manufacturing Processes at Purdue University.

**Plant Engineering Handbook.** William Staniar, Editor-in-Chief. New York, McGraw-Hill Book Company, Inc., 1950. 2,007 pp., illus., diagrs. $15.

This handbook was written by about 37 specialists from 46 companies and five colleges. It covers aspects of management, plant construction and maintenance, equipment, processes, materials, and more general topics. Aspects of management included are basic industrial costs and cost reduction, supervision, work simplification, incentive wage methods, job evaluation plans, and patents and copyrights. There is an extensive section on power plants, refrigeration, industrial piping, mechanical power transmissions, antifriction bearings, lubrication, hydraulic power systems, and mechanical packings are among other sections on equipment. Discussions are included on instrumentation and control, power distribution and lighting, and electrical speed control, and on plant fire control, industrial water purification and treatment, industrial process air conditioning, trade waste disposal, and pneumatic conveying (including dust and fume control). Among the processes discussed are welding, materials handling, crushing and grinding, and drying. Final sections deal with metallurgy and corrosion, heat transfer and heat-transfer properties of materials, physics in the industries, graphical mathematics, vibration and its control (including noise silencing), containers and packaging equipment, industrial glass, and plastics.

## SCIENCES, GENERAL

### *ASTRONOMY*

**Stellar Evolution.** Otto Struve. Princeton, N. J., Princeton University Press, 1950. 266 pp., illus., diagrs. $4.00.

In delivering the Vanuxem Lectures at Princeton University in 1949, Dr. Struve examined the present state of knowledge on the origin and evolution of single stars, and particularly of close double stars. This book is the result. Intended for physicists, chemists, geologists, and others, it is suitable for the layman although technical details are included to show how the results of stellar research have been obtained.

### *MATHEMATICS*

**Dirichlet's Principle, Conformal Mapping, and Minimal Surfaces.** R. Courant. With an Appendix by M. Schiffer. New York, Interscience Publishers, Inc., 1950. 330 pp., diagrs. $4.50.

The author's purpose is to develop Dirichlet's Principle together with applications to conformal mapping and to the theory of minimal surfaces. Chapter headings include Dirichlet's Principle and the Boundary Value Problem of Potential Theory, Conformal Mapping on Parallel-Slit Domains, Plateau's Problem, The General Problem of Douglas, Conformal Mapping of Multiply Connected Domains, and Minimal Surfaces with Free Boundaries and Unstable Minimal Surfaces. Bibliographies are provided for all chapters. An appendix on Some Recent Developments in the Theory of Conformal Mapping is contributed by Professor Max Schiffer of Princeton University and the University of Jerusalem, with a list of 47 references. Dr. Courant is associated with the Institute for Mathematics and Mechanics at New York University.

## THERMODYNAMICS

**Thermodynamics Applied to Heat Engines.** E. H. Lewitt. 4th Ed. London, Sir Isaac Pitman & Sons, Ltd., 1950. 758 pp., diagrs. 30*s*.

In this new edition of an engineering textbook last revised in 1943, six new chapters have been added, and various sections of the previous edition have been enlarged. Gas Turbines and Jet Propulsion, High-Speed Engine Indicators, Rotary Compressors, and Variable Specific Heat Calculations are among the new chapters, and new material is included elsewhere on fuels, combustion, and heat-transfer calculations. The author is Lecturer in the Department of Mechanical Engineering at the Imperial College of Science and Technology at South Kensington.

**Heat Insulation.** Gordon B. Wilkes. New York, John Wiley & Sons, Inc., 1950. 224 pp. illus., diagrs. $4.00.

The author's purpose is to bring together scattered information on heat insulation for engineers, engineering students, and architects. Material not easily located elsewhere is brought together on such subjects as reflective insulation, test equipment, laboratory methods, and complete tables of conductivity values, specific heat data for heat insulators, and emissivity data. Fundamental formulas for steady heat flow, moisture in insulation, and economics of insulation are also covered, and there is a bibliography of 128 books and articles. Much of the research data and material on research methods has been developed by Professor Wilkes and his colleagues at the Heat Measurements Laboratory at the Massachusetts Institute of Technology.


# *I.A.S. National Meeting Schedule*

**Wright Brothers Lecture—U. S. Chamber of Commerce Auditorium, Washington, D.C.—December 16**

**Nineteenth Annual Meeting—Hotel Astor, New York, January 29–31, February 1, 1951**

**[Sixth Annual Flight Propulsion Meeting—Hotel Carter, Cleveland—March 16, 1951**

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee no later than 5 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

**All correspondence should be addressed to:**

**The Meetings Committee, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.**

# I.A.S. News

(*Continued from page 11*)

## *Meet Your Section Chairmen*

### Henry H. Kerr

Detroit Section

Henry Hampton Kerr had completed approximately 1 year of undergraduate work at Cornell University before the United States entry into World War I. Entering the U.S. Army in 1917, he was commissioned a Second Lieutenant and was attached to the Aviation Section of the Signal Corps. The following year, he received his rating as a Military Aviator and was assigned to Kelly Field as a Primary Flight Instructor. After his discharge from the service in 1919, he returned to his interrupted studies and was graduated in 1921 from Cornell with a B.S. degree in Mechanical Engineering. He retained his commission and rating until 1925.

His first employment was with the Illinois Tool Works in 1921. Four years later, he became Vice-President and Secretary of the Daniel Woodhead Company, which dealt in Electrical Supplies. In 1928, he made his first professional appearance on a civilian basis in the field of aeronautics when he was made Maintenance Manager for Rapid Air Lines in South Dakota.

The next year, he became associated with Bendix Products Division, Bendix Aviation Corporation. As Assistant Manager and Service Manager of the Landing Gear Department, he was intimately concerned with the design and development of airplane wheels, brakes, oleos, and other hydraulic apparatus.

After acting as West Coast Sales and Engineering Representative for the Weatherhead Company from 1941 to 1943, he joined Hayes Industries. Then, in 1946, he went with United States Rubber Company, where he was placed in charge of aircraft wheel and brake development for the Tire Division. Today, he is the Manager of the New Products Development Department, Tire Development Division, U.S. Rubber. His duties cover the development of special products and new processes for the Tire Division.

Mr. Kerr holds various patents on brakes and wheels, some of which are being used in current production methods. Two of his papers, "The Airplane Brake" and "Weight Reduction of Aircraft Braking Systems Through Use of Reverse Thrust Propellers," have been published in the I.A.S. and S.A.E. publications. He had also delivered lectures on these subjects at I.A.S. and S.A.E. meetings.

Mr. Kerr was born in Evanston, Ill., on November 30, 1896. He married Marie Van Wie, and they are now the parents of a boy, aged 13, and two girls, aged 11 and 17.

### J. Parker Van Zandt

Washington Section

John Parker Van Zandt, who was born in Chicago on January 16, 1894, spent 7 years at the universities of Chicago, Washington, and California. It was at the last institution that he received both his B.S. degree in 1914 and his Ph.D. degree in 1917. As soon as he had completed his final course at the University of California, he left for France to serve as a volunteer in the French Army. He was transferred to the Aviation Section of the U.S. Signal Corps, with the rank of Lieutenant and a rating of Military Aviator, upon the arrival of the American forces in Europe. He was then placed in charge of radio installation and research of the Aircraft Radio Branch.

From 1919–1923, he served variously as Flight Instructor with the California Forest Fire Patrol, Assistant Chief of Air Services Engineering School, and Chief of Air Navigation Branch. He was subsequently Secretary of the Committee on Civil Aviation for the Department of Commerce and assisted in the preparation of the first Air Mail and Air Commerce acts. For the 2 years prior to his resigning his commission as Captain in January, 1926, he served as Special Assistant to the Chief of the Air Services.

Mr. Van Zandt then became Chief Pilot and Operations Manager for Stout Air Services. This was followed by positions as President and General Manager of Scenic Airways and Vice-President of United Aviation Corporation. Leaving the domestic air-line scene in 1929, he was appointed European Representative for Ford Motor Company in charge of aviation sales in 19 foreign countries. It was in this capacity that he gave the first European demonstration of the Ford Tri-Motor. Returning from Europe, he became associated with Chicago's A Century of Progress International Exposition, first as Head of Aviation and Automotive Exhibits, then as Sales Supervisor for the entire exhibit, and, finally, as Foreign Commissioner in Europe in charge of Foreign Governments' participation.

After joining the Pacific Division of Pan American Airways, Inc., in 1935, he was made responsible for establishing and operating the base in Honolulu. This was followed by his being appointed General Representative and District Traffic Manager at Manila, P.I.

Back in the United States again, Mr. Van Zandt became Economic and Technical Consultant for the Civil Aeronautics Board and Reconstruction Finance Corporation, Director of the Office of Air Transport Information, and Director of Aviation Research for The Brookings Institution. In 1947, he was made President of the Aviation Research Board. This year, 1950, he became Deputy for Civil Aviation to the Assistant Secretary of the Air Force, where his work concerns the relationship of military and civil affairs.

Mr. Van Zandt, who holds pilot's license No. 17, is married to the former Lydia Begole. He was Editor-in-Chief of the 1948 edition of the *World Aviation Annual.*

PAA

# ANOTHER GREAT AIRLINE JOINS THE DC-6 FAMILY!

Purchase by Pan American of a fleet of DC-6Bs again focuses world attention on this advanced Douglas air transport with its heritage of more than 13 billion passenger miles of dependable service. This brings the number of major airlines in the illustrious DC-6 family to nineteen.

Longer, heavier, more powerful than the standard DC-6, the DC-6B was selected by Pan American because engineering and operations studies convinced them it was the finest in its class for their international requirements.

High performance with low operating costs, superior take-off and cruise performance with four Pratt & Whitney R2800-CB 17 engines, and pressurization for flight up to 25,000 feet are features of this new transport.

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30TH ANNIVERSARY YEAR

# I.A.S. Sections

## Dayton Section

W. A. Barden, *Secretary*

At its first meeting of the 1950–1951 season, September 28, the Dayton Section was fortunate in having Dr. Max M. Munk, Naval Ordnance Laboratory, White Oak, Md., speak "On Turbulent Fluid Motion."

Approximately 50 members and guests attended the dinner and reception preceding the meeting, and another 25 joined the group to hear Dr. Munk.

Dr. Munk's paper was well received as evidenced by the high level of interest and the extent of discussion following his presentation.

A. F. Arcier, retiring Chairman, introduced Ezra Kotcher as the new Chairman, who in turn introduced the other new officers of the Section. Mr. Kotcher then introduced Major Gen. Grandison Gardner, the new Commandant of the U.S.A.F. Institute of Technology, and Major E. A. Blue, the new Chairman of the I.A.S. Student Branch at the U.S.A.F.I.T.

E. A. Ledeen was appointed as the Representative to the Nominating Committee for Area Councillors.

## Ottawa Aeronautical Society

J. C. Finlayson, *Secretary*

The 1950–1951 season got under way with the holding of the first session on September 13.

The speaker was Prof. A. R. Collar, Sir George White Professor of Aeronautical Engineering, University of Bristol, England, who gave a most interesting address on "The Influence of Aeronautics on History." Professor Collar gave a brief sketch of the factual history of aeronautical effort up to the time of the first flight, mentioning the contributions made by Leonardo da Vinci, Newton, Sir George Cayley, Hanson, Stringfellow, Maxim, Langley, Lilienthal, and Mach. He indicated that tremendous advances were made during the decade 1935–1945 and that it was still early to assess the full effects of this intensive development period. He then discussed some of the apparent changes wrought by aviation, such as the transfer of population in Britain during the war brought about by air raids and the change in national outlook toward the enemy which these caused. He spoke of the influence on the British nation resulting from a peak force of 2,000,000 persons employed in the aircraft industry during the last war and noted that some of the visible evidence included the appearance of light alloys in bridges and in ship building. He concluded his talk with the presentation of a brief list of the more unusual uses to which aviation has been put, including fish spotting, seeding from the air, archaeological discovery, and highway traffic control.

The speaker was introduced by Air Marshall G. O. Johnson, Chairman of the Society, and a vote of thanks was tendered by Dr. J. J. Green. Included in the audience were some 15 members of the Commonwealth Advisory Aeronautical Research Council, which was then holding its second session in Ottawa. There was an exceptional turnout of some 70 members of the Society.

## Texas Section

Russell E. Berger, *Secretary*

The September 15 meeting was held at the American Legion Hall in Grand Prairie. During the course of the meeting, a movie, *British Aircraft in Review*, was shown. This film that was made of the 1949 show of the Society of British Aircraft Constructors proved to be extremely interesting and illustrated British progress. Fred N. Dickerman, Chief Engineer, Chance Vought Aircraft Division, United Aircraft Corporation, supplied further enlightening comments and explanations as he had recorded them at the show. He answered the many questions arising concerning the British exhibition.

# Student Branches

## Academy of Aeronautics

An election for a new treasurer was called at the September 7 meeting, inasmuch as Treasurer Anthony Martellucci has entered the U.S. Navy. Jerome Minerva was elected to serve as the new treasurer. Chairman James Sneden presided; 20 persons attended.

## Air Force Institute of Technology

New officers, all members of the Class of 1951, were elected as follows: Chairman, Major Eugene A. Blue; Vice-Chairman, Major Robert W. West; Secretary, Capt. Harold F. Wienberg; and Treasurer, Lt. Mark Farnum, Jr.

During the summer session, the students of the Class of 1951 visited a number of selected aircraft plants and laboratories throughout the United States and attended a series of lectures designed to familiarize them with the aircraft industry and the U.S.A.F. phase of research and development, supply, maintenance, and procurement. Visits to industrial concerns were included.

## Indiana Technical College

Chairman Donald Wolfe opened the September 20 meeting which was attended by 19 persons. A film, *Camera Thrills of World War II*, was shown.

LaVern J. Sweida was chosen as the outstanding graduating student of aeronautics for the 1950 school year and was presented with an engraved key and a cash award.

## Parks College of Aeronautical Technology

The following officers for the new term were elected at the September 14 meeting: Chairman, George Holland; Vice-Chairman, Gene Swick; Treasurer, William Reitmeyer; Secretary, Ralph Hallenborg; and Corresponding Secretary, Leonard Gaines.

## Purdue University

The meeting of October 3 was opened by Chairman Walter H. Larrimer, Jr., and was attended by 125 persons. The Purdue Gliding Club showed two films on the Club's activity in recent national soaring meets. Dr. Milton U. Clauser, Head, School of Aeronautics, Purdue, said a few words on the close relationship between the research scientist and the engineer in the field of aeronautics.

# Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. Members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th Street, New York 21, N.Y.

# Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

## Transferred to Associate Fellow Grade

**Frost, Richard H.,** B. of Ae.E., Senior Project Engineer, Stanley Aviation Corp.

**Young, Clarence M.,** LL.B., Vice-President, Pan American World Airways System.

## Elected to MEMBER Grade

**Cartabiano, Angelo,** B. of Ae.E., Aero. Engineer P-4, Naval Air Material Test Center (Pt. Mugu).

**Eckert, Hans U.,** Dipl. Eng., Aero. Engineer & Consultant, Aerial Development Div., Air Materiel Command, U.S.A.F., Wright-Patterson Air Force Base.

**Ellis, Macon, Jr.,** B.S. in A.E., Aero. Research Scientist & Head, 9-Foot Supersonic Tunnel Section, Langley Aero. Lab., N.A.C.A.

**Eshleman, Arthur L., Jr.,** B.S., Engineering Designer, Douglas Aircraft Co., Inc. (Santa Monica).

**Glass, Irvine I.,** Ph.D., Research Assoc., Institute of Aerophysics, University of Toronto.

**Gruber, Alan R.,** S.M., Engineer, Nuclear Reactor Design, Nuclear Development Associates, Inc.

**Hancock, Aubrey H. T.,** Senior Designer Draughtsman, Aero Controls, Ltd.

**Higgins, Edward H.,** B.Sc. (Aero.), Project Engineer, Canadair, Ltd.

**Hoffman, H. J.,** B. of Ae.E., Leadman, Hydraulic & Landing Gear Group, Douglas Aircraft Co., Inc. (El Segundo).

**Kauffman, William M.,** B.M.E., Aerodynamic Scientist, Aerodynamic Div., N.A.C.A. (Washington, D.C.).

**Kippenhan, Charles J.,** Ph.D., Asst. Prof. of Mechanical Engineering, Washington University.

**Klapproth, John F.,** A.B., Aero Research Scientist, Lewis Flight Propulsion Lab., N.A.C.A.

**Mortimer, Arthur,** Aircraft Instrument & Navigation Instructor-Engineer, Britavia, Ltd.

**O'Connell, Edison E.,** M.S.M.E., Mechanical Engineer, Naval Air Material Test Center (Pt. Mugu).

**Richez, Pierre,** Ing. des Arts et Métiers, Chief Engineer, Dept. of Aviation, Société Generale D'Equipments.

**Schneider, Arthur J. R.,** Ph.D., Head, Fluid Mechanics Section, Naval Ordnance Test Station (Pasadena).

**Scott, Walter H.,** M.S. in Aero. Eng., Asst. Head, Guided Missiles Group, Grumman Aircraft Engineering Corp.

**Specht, Edward J.,** B.M.E., Aircraft Gas Turbine Specialist, General Electric Co. (Los Angeles).

**Spinney, Franklin C.,** Capt., U.S.A.F.; Chief, Rescue Unit, Engineering Div., Air Materiel Command, Wright-Patterson Air Force Base.

**Warfield, Calvin N.,** Ph.D. (Physics), Physicist, Applied Physics Lab., The Johns Hopkins University.

## Transferred to MEMBER Grade

**Armstrong, William F., Jr.,** B.S., Aero. Engineer—Project Master Planner, McDonnell Aircraft Corp.

**Dickman, Paul R.,** B.A.E., Applied Loads Engineer, Grumman Aircraft Engineering Corp.

**Laufer, John,** Ph.D. in Aero., Physicist, National Bureau of Standards, Washington, D.C.

**Lloyd, Richard H.,** D.Sc.Ae., Project Engineer, Bell Aircraft Corp.

**Picken, Harry B.,** B.S.E. in Ae.E., Chief Engineer, Weston Aircraft, Ltd.

**Robinson, Robert Frank,** M.S. in Ae.E., Instructor, School of Aero., Purdue University.

**Spath, Richard M.,** M.S.E. (Aero.), Research Engineer, Willow Run Research Center.

## Transferred to Associate Member Grade

**Sleight, Robert B.,** Ph.D. (major in Psychology), Research Psychologist & Asst. Prof. of Psychology, Psychological Lab., Institute for Cooperative Research, The Johns Hopkins University.

## Elected to Technical Member Grade

**Armstrong, Ruth D.,** Editorial Asst., McGraw-Hill Publishing Co.

**Grossmith, Geoffrey J.,** Design Draftsman, A. V. Roe Canada Ltd. (Malton).

**Howell, Allison B.,** M.E., Squadron Leader, R.C.A.F.; Asst. Resident Engineering Officer at A. V. Roe Canada Ltd.

**Neumann, Temple W.,** B.Sc.M.E., Engineer-Project, Service Engineering Group, Boeing Airplane Co. (Wichita).

**Peres, Alberto L.,** Capitao Aviador, Ministerio da Aeronautica do Brasil.

**Reis, Norbert N.,** Asst. Head of Quality Control, Israeli National Air Lines, "El Al."

## Transferred to Technical Member Grade

**Abbott, Lawrence S.,** B.S.Ae.E., Design Draftsman, Cessna Aircraft Co.

**Adams, Kenneth W.,** B.S., Test Lab. Technician, Boeing Airplane Co. (Wichita).

**Albiston, Weston B.,** B. of Ae.E.

**Anderson, Paul H.,** B.S. in Ae.E., Mathematician "B" (Aerodynamics), North American Aviation, Inc.

**Ashby, George C., Jr.,** B.S.

**Baird, John,** B.S.M.E., Research Analyst "B," North American Aviation, Inc.

**Baker, Robert C.,** B.Ae.E., Test Engineer, General Electric Co. (Ohio).

**Baldasare, Paul,** B.A.E.

**Bartz, Harry W.,** B.S.A.E., Engineering Design Draftsman, Bell Aircraft Corp.

**Beall, Douglas L.,** B.S.M.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

**Bederman, David,** B.S., Engineering Draftsman, Class "A," Consolidated Vultee Aircraft Corp. (San Diego).

**Bendot, Joseph G.,** B.S. in M.E., Engineering Trainee, Structures Dept., The Glenn L. Martin Co.

**Biro, Louis,** B.Aero., Flight Test Engineer, Piasecki Helicopter Corp.

**Black, Samuel,** B.S., Mechanical Engineer, Air Controls, Inc.

**Blichner, Olva,** B.S.Ae.E., Graduate Student, University of Minnesota.

**Bloom, Kenneth F.,** B. of Ae.E., Engineer—Draftsman "A," Consolidated Vultee Aircraft Corp. (San Diego).

**Bode, James L.,** B.S.Ae.E., Pilot, Delta Airlines, Inc.

**Bristol, Fred W., Jr.,** B.S.

**Brown, James N., Jr.,** B.S. in Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

**Brown, Richard B.,** B.S. in Ae.E., Teaching Fellow, Virginia Polytechnic Institute.

**Bruner, Patricia L.,** B.S. in Ae.E., Aerodynamicist, North American Aviation, Inc.

**Bruyette, Gerald W.,** B.M.E. (Aero.).

**Buckley, Thomas P.,** Engineer in Weights & Standards Dept., Sikorsky Aircraft Div., United Aircraft Corp.

**Burnett, John H.,** B.S.A.E., Jr. Engineer—Engineering Airframes Project, Boeing Airplane Co. (Wichita).

**Calhoun, William D.,** B.S.

**Chase, Rodney S.,** B.S.Ae.E., Structural Draftsman "B," Douglas Aircraft Co., Inc. (Santa Monica).

**Christensen, David A.,** B.S. in Ae.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

**Christian, Charlotte W.,** B. E.

**Christian, Wallace J.,** B.E., Flight Test Analyst, Ryan Aero. Co.

**Christmas, Harlan F.,** Mechanic, Combs-Hayden, Mountain States Aviation, Inc.

**Clark, James M.**

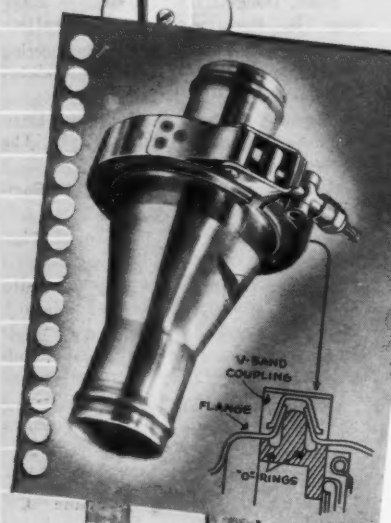
**Clemen, Arthur T.,** M.S.E. in Ae.E., Aerodynamicist, Consolidated Vultee Aircraft Corp. (Ft. Worth).

**Dammer, William H.,** B.Ae.E., Aero. Engineer, Boeing Airplane Co. (Seattle).

**Dickinson, Robert L.,** B.S.M.E. (Aero.), Student, University of Oklahoma.

**Drennan, L., Jr.,** M.S., Senior Stress Analyst, The Glenn L. Martin Co.

ENGINEERS NOTEBOOK

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**Edgar, John M.,** M.S. (Aero.E.), Aerodynamicist "B," Douglas Aircraft Co., Inc. (Santa Monica).

**Ettenson, Norman J.,** B.S.C.E. (Aero.).

**Evans, Keith A.,** B.S. in A.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

**Ferrara, Caesar L.,** B. Aero. E.

**Flaa, Ole Peter,** B.S. in M.E. (Aero.), Experimental Engineer, International Harvester Co.

**Fletcher, Herman S.,** B.S.

**Foster, Alfred D.,** B. of Ae.E., Supervisor, H. L. Yoh Co.

**Fritz, George F.,** Engineering Sheet Metal Draftsman, Douglas Aircraft Co., Inc. (El Segundo).

**Gann, Harry S., Jr.,** B.E.

**Gay, Shelton M., Jr.,** B.S.Ae.E., Student, Virginia Polytechnic Institute.

**George, Dean B.,** B.S. in Ae.E., Weights Calculator, Weight Control Group, Bell Aircraft Corp.

**Gowin, Norman E.,** B.S.Ae.E., Aerodynamicist, Bell Aircraft Corp.

**Greer, Dick L.,** Layout Man "B," Herman Nelson Corp.

**Griep, Paul C.,** B.S.E.

**Groff, Charles,** B.S.Ae.E., Inspector, Jet Ignition Systems, General Lab. Assoc., Inc.

**Haberstroh, Robert D.,** B.S.M.E. (Aero.), Graduate Student, Massachusetts Institute of Technology.

**Hahn, Edward J.,** B.S. in Ae.E., Liaison Engineer, Boeing Airplane Co. (Seattle).

**Hanson, Donald V.,** B.Ae.E., Engineer, North American Aviation, Inc.

**Happ, William D.,** B.S., Jr. Engineer, B-47 Liaison Group, Boeing Airplane Co. (Seattle).

**Harshman, D. L.,** B.S. in M.E. (Aero.), Jr. Engineer, Wright Aero. Corp. Div., Curtiss-Wright Corp.

**Hart, Marvin E.,** B.S., Aero. Engineer GS-5, Ames Aero. Lab., N.A.C.A.

**Hawkshaw, J. K.,** B.A.Sc. (Aero.), Jr. Engineer, Weston Aircraft Co., Ltd.

**Hayes, John M.,** B. of Ae.E., Engineering Draftsman, Consolidated Vultee Aircraft Corp. (Ft. Worth).

**Heaton, Desmond L.,** Engineering Draftsman "C," Douglas Aircraft Co., Inc. (Santa Monica).

**Heinrich, Allyn M.,** A.A. in Ae.E., Engineering Draftsman, Cessna Aircraft Co.

**Holt, Donald G.,** B.S. in A.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

**House, Dave C.,** Jr. Engineer "B,", Controls Group, Boeing Airplane Co. (Seattle).

**Hoyler, Wilburne F.,** B.S., Engineering Designer "B," Consolidated Vultee Aircraft Corp. (Ft. Worth).

**Huff, Lewis L.,** B.S. in Aero.

**Hunter, Robert F.,** B.S.Ae.E., Engineer, Douglas Aircraft Co., Inc. (Long Beach).

**Johnson, Jack C.,** B.S.Ae.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

**Kamm, Arthur J.,** A.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

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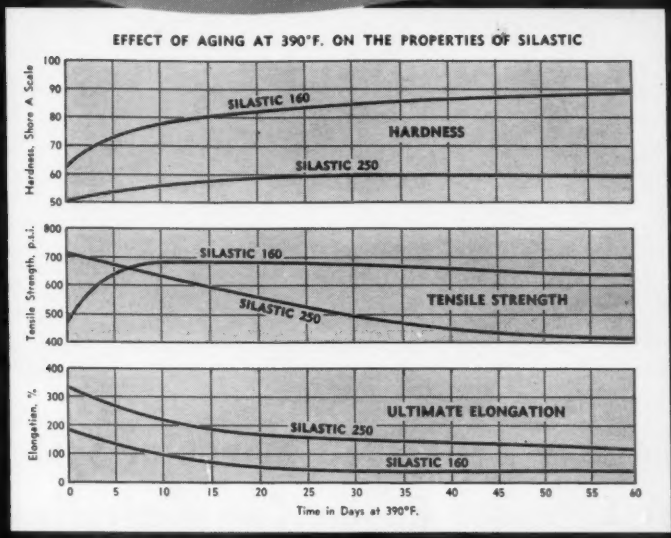


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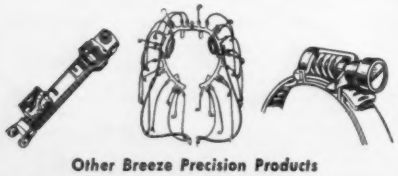

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# Personnel Opportunities

**This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.**

## Wanted

**Aeronautical Engineer**—Civil Service position open in office of Bureau of Aeronautics Representative, 15 S. Raymond Ave., Pasadena, Calif. Work involves administration of Government contracts for jet propulsion and other aircraft devices. Engineering degree and 4 years of progressive professional engineering experience in fluid mechanics and combustion applicable to jet propulsion required. Advanced degree and experience in wind-tunnel testing desirable. Entrance salary $6,400 a year, Grade GS-12. Applicants should submit record of education and experience on Civil Service Form 57.

**Aircraft Dynamics Engineers**—For research work in the fields of: subsonic and supersonic flutter, vibration, dynamic loads; stability and control of supersonic missiles; and helicopter dynamic problems. Applicants must have good background in fundamentals of applied mechanics and mathematics. Advanced degree or previous experience in field is essential. Salaries commensurate with training and experience. Cornell Aeronautical Laboratory, Inc., Employment Office, 4455 Genesee St., Buffalo 21, N.Y.

**Electronics Engineer**—With interest in instrumentation and automatic control to join instrument development group at the Wind Tunnels Laboratory. Starting salary $3,100–$3,825 per annum. Apply Civilian Personnel Division, Aberdeen Proving Ground, Md.

**Research Engineers**—The Ballistic Research Laboratories have vacancies in the grades GS-14 ($8,800) and GS-13 ($7,600) for mechanical, electrical, and electronic engineers. The positions involve evaluation of complete weapons systems including electronic and ballistic components, and the supervision of related research and experimentation necessary to obtain basic data for such evaluation. Applicants should have good background in some or all of applied mathematics, circuit analysis, fire control, analog computers, and radar and should have research experience. Address inquiries, mentioning this notice, to Commanding General, Aberdeen Proving Ground, Md., Attention: Director, Ballistic Research Laboratories.

**Development or Experimental Engineer**—Graduate engineer with 5 years' experience in applied engineering, preferably in development. Familiar with turbojet engines. Mechanical design ability with background in thermodynamics and combustion. Capable of supervising development tests and writing good reports. Please direct reply to Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif.

**Thermodynamicist**—Graduate engineer to perform theoretical and design analysis of gas-turbine-type power plants. Must be analytical with practical realization of manufacturing problems. Background of thermodynamics, fluid dynamics, and heat transfer necessary. Five years' experience in applied engineering in these subjects. Must be capable of writing good reports. Please direct reply to Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif.

**Aerodynamic, Vibrations, and Senior Layout Engineers**—Must have minimum of 5 years' aircraft experience, preferably in helicopters. Please submit full details concerning education, background experience, and capabilities. Address: Chief Engineer, Kellett Aircraft Corporation, Central Airport, Camden 11, N.J.

**Thermodynamicist**—Advanced training with Master's or Doctor's degree. Aeronautical experience desirable. **Structures Engineer**—Aeronautical degree with at least 3 or 4 years' aircraft experience in structural analysis. Civil Engineers with similar experience will also be considered. **Weight Engineer**—Technical graduate, considerable experience in preliminary design in connection with weights work. Should possess estimating ability. **Senior Development Engineers**—Group Leader; educational background physics, or electrical, or mechanical engineering. Applicable experience in such fields as gyros, servos, intricate machine design, mechanics, or dynamics. Technical ability is of foremost importance. **Helicopter Engineers**—(A) Mechanical Engineers experienced in engine work, helicopter design, or aircraft control systems. (B) Aeronautical or Structural Engineers with a degree plus 4 to 5 years' experience in sheet-metal construction. (C) Electrical Installation Engineer with a college degree or equivalent, 2 to 3 years' experience in actual installation design work. NOTE: Profound interest in the designing and building of helicopters is essential for these positions. **Chief, Systems Test Engineer**—Technical graduate; at least 3 to 5 years of experience including various types of systems test; 60 per cent electronics and related experience such as instrumentation work, leadership ability essential. **Test Engineers—Missiles**—Electronics or Radio Engineering degree or equivalent with considerable experience in electronic circuitry. **Senior Dynamics Engineer**—A Master's or Doctor's degree in applied mathematics or physics, or aeronautical engineering with emphasis in dynamics and vibrations. Some experience in servomechanisms, flutter and vibrations, or stability desirable. Position also available for Electronics Engineer with mathematical ability and interest in dynamics work. **Research Dynamicist**—Advanced education in applied mathematics with experience in operations research. Include a comprehensive résumé with each inquiry, and address all replies to: R. C. Marks, Manager, Engineering Personnel, Bel Aircraft Corporation, P. O. Box 1, Buffalo 5, N.Y.

**247. Aircraft Design Engineer**—Old, established eastern aircraft company wants additional qualified designers. This is not an appeal for drafting and layout people but for those who, by experienced background, have proved themselves to do dependable original design work on hydraulics installations, power plants, control systems, landing gears, and mechanical devices for aircraft. It is required that applicants are willing to do their own basic design layouts. In letter of application give details of experience, age, and salary requirements.

**245. Assistant Professor of Aeronautical Engineering**—To teach aircraft structures, aircraft structural design, and static testing in Aeronautical Engineering Department of state university. Excellent opportunity for applicant who can assume responsibility for structures program. Send brief outline of education and experience with reply. Salary dependent upon qualifications.

**229. Electronics Engineer or Physicist**—To assist in evaluation of missile-guidance systems from operational or user's point of view—high level organization. Location: Washington, D.C. Submit complete résumé and references. Salary dependent on qualifications.

**220. Assistant Sales Manager**—Expanding market of aircraft instrument manufacturer opens new position with attractive future available to qualified man. State aviation experience, including sales, engineering, and flying ability; also education, and starting salary desired.

**The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.**

## Available

**254. Sales Engineering Representative**—Sales management experience of products requiring high-level engineering in aviation and general industry. Products electromechanical in nature can be represented from an engineering and sales standpoint in the Western states. Location of office—Los Angeles.

**253. Mechanical and Aeronautical Engineer**—Age 43. Seventeen years of experience in Europe, Canada, and the United States. Five years as chief inspector for Air Ministry in Warsaw; 2½ years as technical manager of factory producing instruments for aircraft; 2 years as inspector and later chief engineer with aircraft factory in Canada; 3 years as chief engineer in charge of design of jet helicopter in U.S.A.; 1 year in charge of combustion research; for 1 year conducted research on ram-jets for United States Air Force; 2 years as vice-president in charge of engineering and research of laboratory carrying on research on combustion for U.S. Army, Navy, and industry. Languages: English, French, Polish, Russian, and slight knowledge of German and Czechoslovakian.

**251. Aeronautical Engineer**—B.S. in Aeronautics, Massachusetts Institute of Technology, 1936. Fourteen years' experience in aircraft and guided-missile design and structural analysis, including 7 years as project stress engineer on Army, Navy, and commercial aircraft; 3 years as project engineer on fighter and cargo aircraft; 4 years as chief of structures and project supervisor on guided missiles. Desires responsible position in project or structures department, or production engineering, entailing shop liaison. Capable of assuming full responsibility of departments. Age 36.

**250. Service—Maintenance—Liaison—Administration**—Purdue University Graduate, June, 1949. B.S. degree in Air Transportation. Has private pilot's license, A. & E. mechanic's license, ground instructor rating in A. & E. Five years' retail sales experience. Business administration and technical educational background. Twenty-six months in U.S. Air Force. Member of Civil Air Patrol. Desires position offering opportunity for variety of experience and advancement in service, maintenance, liaison engineering, or administrative work. Location open. Age 25. Complete résumé upon request.

**GRADUATE PHYSICAL ORGANIC AND INORGANIC CHEMISTS.** Ph.D. required. Men with firm academic background and industrial experience for research and development work in the field of liquid and solid propellants. Should have knowledge of kinetics, thermo-chemical measurements, high-polymers, interior ballistics, resins and nitro-compounds. Firm background of mathematics, plus the ability and desire for both group and independent research.

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**248. Junior Aeronautical Engineer**—B.S. Major in preliminary design; one year of mechanical design experience dealing with machine parts. Interested in design opportunities and technical report writing. Recipient of I.A.S. Student Branch Lecture Award. Salary and location open.

**246. Research and Development Engineer**—Desires position as technical assistant to executive engineer, technical liaison and coordination engineer between technical groups or special technical assignments, or project engineer with aircraft and/or missiles company. Experience includes several years of working with internationally known authority in technical aeronautics and many years in aircraft industry. Education includes pertinent science graduate pursuits, as well as usual undergraduate training in science. Can offer suitable business and practical technical experience along with supervision in applied technical aeronautics, with early experience in basic research.

**244. Field Representative**—Naval Commander, retiring about January, 1951; B.S. degree from U.S. Naval Academy, Ae.E. degree from California Institute of Technology. Naval Aviator since 1935; 4,000 hours logged flight time in all types, mostly single-seater fighters. Especially qualified for field representative job; familiar with aeronautical material commands in both U.S. Navy and Air Force.

**228. Aeronautical Engineer**—Doctor of Engineering. Experience of 23 years includes aircraft detail design, development, design and preliminary stress analysis of structural, mechanical, and hydraulic components of aircraft, preliminary design, design of complete commercial and military aircraft; flight testing, air-line engineering and maintenance, and considerable shop experience. Has conducted Airplane Design Course at eastern college. Desires responsible position in research, development, or design organization.

**227. Engineer-Instructor**—B. Aero. E., M. Aero. E., Professional Engineer. Two years of aerodynamics in stability and control, performance, air loads, wind tunnel. One and one-half years as research engineer with precision instrument firm on East Coast. Experience includes precision experimental instrument design and test, purchasing, shop liaison. Now finishing second annual contract as Instructor in Aeronautical Engineering in New England College. Would prefer Assistant Professorship in New York or New England area or responsible industrial position. Will relocate if attractive. Full knowledge of present employer.

**226. Aeronautical Engineer**—B.S. in Aeronautical Engineering (M.I.T.), A.E. (N.Y.U. Engineering College). Eleven years' experience in airplane manufacturing plants and air lines doing engineering research, aerodynamics and structural design—i.e., sonic and supersonic airplane performance and stability; air loads; servomechanism design; stress analysis, etc. Adept at solving problems requiring ingenuity, originality, and the application of engineering principles, mathematics, and physics. Licensed Mechanical Engineer No. 8587 with the California Board of Registration for Civil and Professional Engineers. Five years' high-school teaching experience in mathematics and sciences. Adult Education Credential No. Q 1 6572 for teaching mathematics and social studies in the State of California. Desires responsible position with research or develop-

**GRADUATE MECHANICAL ENGINEERS, CHEMICAL ENGINEERS, or PHYSICISTS** for research design and development work on rockets, rocket components and guided missiles. Firm academic background in mathematics, hydraulics, thermo-dynamics and stress analysis necessary. Experienced in the field of rocketry or allied work. Advanced degree desirable.

Applicant must furnish transcripts of academic record, names of four persons familiar with research ability, complete resume of past experience and salary desired. All correspondence will be kept confidential.

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ment organization in or near an educational institution where a Doctorate in Mathematics and Physics may be obtained. Would be interested in teaching supplemented with research.

**225. Aeronautical Engineer**—Nine years' experience. In airplane manufacture, 3 years covering shop liaison, design of aircraft equipment, and supervision of preparation of technical publications. In air lines, 4½ years in service and flight-test engineering, preparation of maintenance and operating manuals, supervision of design and installation of airplane interiors and furnishings. One and one-half years of training as naval aviator. Has completed to date one-half of, and continuing with, courses leading to B.Sc. in Commerce. Interested in sales and service position with manufacturer or in combined administrative-technical position with air line. Location open.

**224. Aeronautical Engineer**—B.M.E., 1941. Nine years in the aircraft industry, 2½ years as stress analyst on naval aircraft. Past 6½ years as a flight research engineer. At present directing major flight research project to correlate flight and analytically predicted results. Present duties include specifying conditions of flight tests, data to be recorded, instrumentation, calibrations, flight checks, evaluating flight data, conducting theoretical investigations, coordinating work of specialists on project, consultations, writing reports. Desires position, preferably in East, directing flight research programs, or would act as European representative for organization requiring man with extensive technical aeronautical engineering experience. Details of background furnished on request.

**223. Junior Layoutman**—Seven years' experience; 5 years in aircraft industry; past 2 years in civil service at Government arsenal doing plant equipment design and drafting. Wishes to return to aircraft. Desires to locate in Northern New York State but will locate anywhere.

**222. Aeronautical Engineer**—Seventeen years' experience on military aircraft. Specialized in instruments, radio, and equipment. Two years as project engineer on Army liaison plane. Three years as chief draftsman for large aircraft manufacturing corporation. Two years research, in guided missiles, and instrumentation for rocket testing. Interested in position utilizing background of experience to best advantage.

**221. Aeronautical or Mechanical Engineer**—B.S. Degree in Aeronautical Engineering. Graduate student for 1½ years in Aeronautics and Applied Mechanics. Approximately 3 years in the aircraft industry as a senior draftsman and aerodynamicist. Desires a position in stress analysis or aerodynamics and other related engineering work. Will accept position anywhere in the United States or abroad.

**205. Mechanical Engineer**—Licensed Professional Engineer. Eleven years' experience: 2 years of teaching evening classes, Washington University, St. Louis, Mo. Supervisory experience includes 3 years as Chief of Design, 1 year as Project Engineer (power plant), 1 year as Group Engineer (power plant), 1 year as Lead Man (power plant and preliminary design). Active Wright Field and BuAer contacts 1943–1945; active C.A.A. Washington contacts 1945–1946. Experienced in preliminary design (8 years), including practical estimations of manpower (shop and engineering) and material costs. Diversified experience ranges from complete airplane and guided-missile design to components, including liquid-oxygen test devices, injector plates, rocket-motor shells, high-speed bearing application, miniature power plants, and optics systems for seekers. Will consider supervisory or administrative work with a small, aggressive, and well-financed group. Currently holds two Professional (P-6) Civil Service Ratings.

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The extremely high temperatures generated within jet and gas-turbine power units are among today's most challenging aircraft engineering problems.

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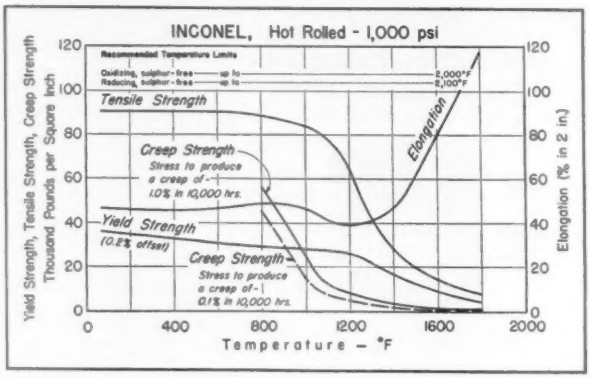


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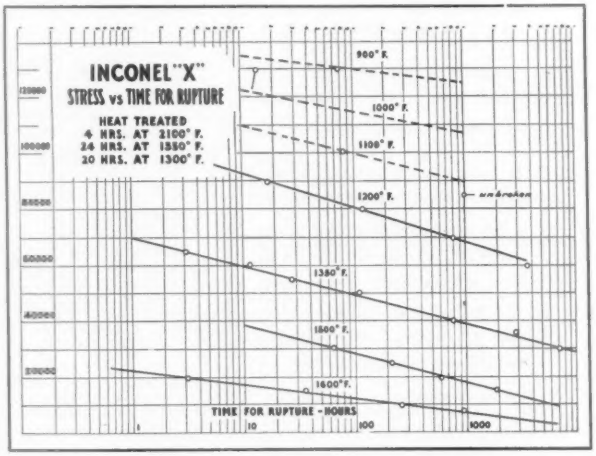


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*Faster speed — up to maximum limit permitted by airframe design.*

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*Much improved take-off and climb—permitting use of shorter runways, with greater safety and better schedules.*

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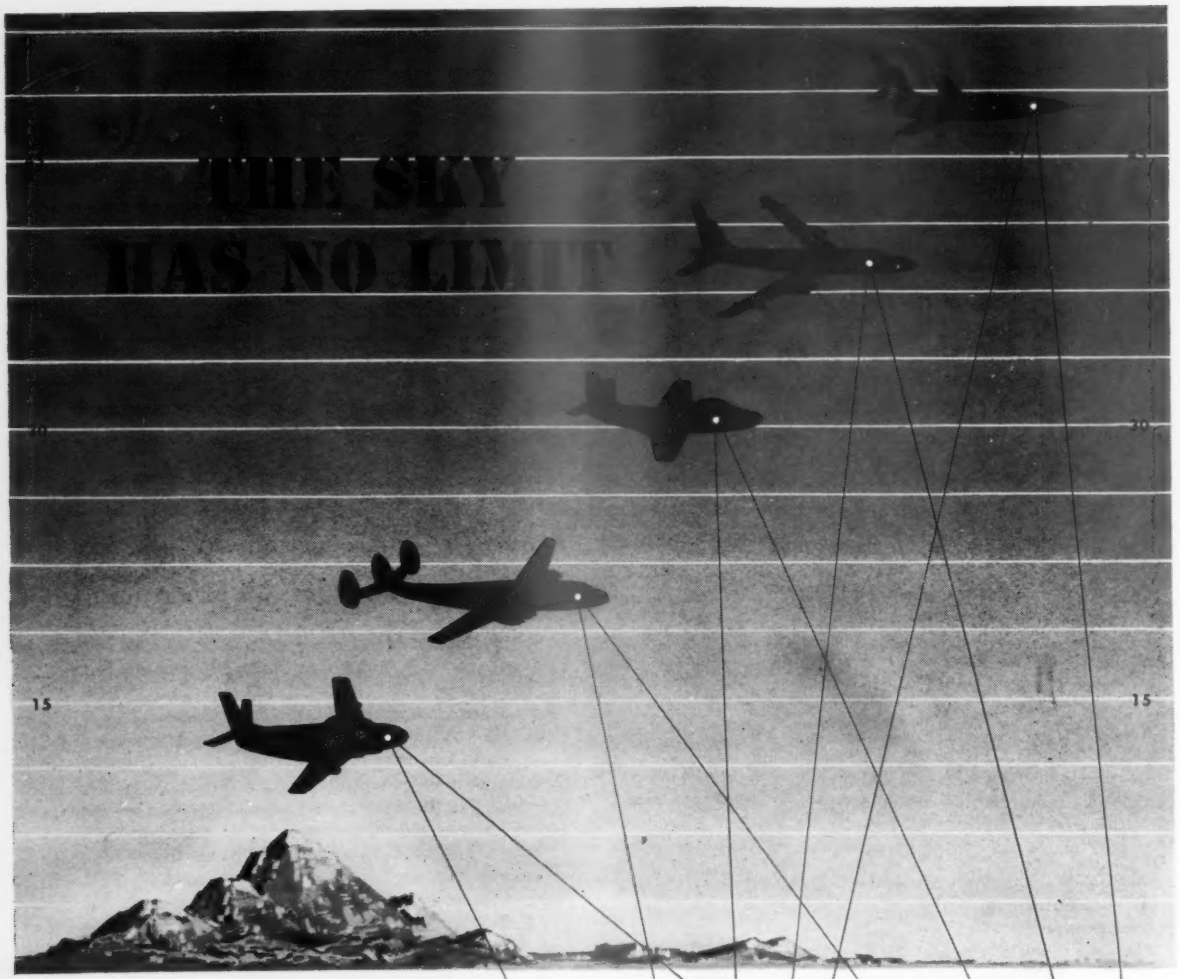


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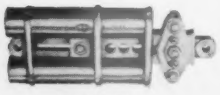

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